federal register

FRIDAY, JUNE 23, 1978
PART III

DEPARTMENT OF LABOR

Occupational Safety and Health Administration

OCCUPATIONAL EXPOSURE TO COTTON DUST

Final Mandatory Occupational Safety and Health Standards

[4510-26]

Title 29—Labor

CHAPTER XVII—OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, DEPARTMENT OF LABOR

PART 1910—OCCUPATIONAL SAFETY AND HEALTH STANDARDS

Occupational Exposure to Cotton Dust

AGENCY: Occupational Safety and Health Administration, Department of Labor.

ACTION: Final Standard.

SUMMARY: This final standard establishes occupational safety and health requirements for occupational exposure to cotton dust. It reflects OSHA's determination, based on evidence that has been placed in the public record of this rulemaking proceeding, that exposure to cotton dust presents a significant health hazard to employees. The standard establishes permissible exposure limit of 200 $\mu g/m^3$ for yarn manufacturing, 750 $\mu g/m^3$ for slashing and weaving operations, and 500 $\mu g/m^3$ for all other processes in the cotton industry and for non-textile industries where there is exposure to cotton dust. Cotton ginning is the subject of a separate regulation, § 1910.1046, published today also in Part III of this FEDERAL REGISTER. The harvesting of cotton and the manufacture of garments from cotton fabrics are not covered by this standard. The cotton dust standard, which is promulgated as 29 CFR 1910.1043, also provides for employee exposure monitoring, engineering controls and work practices, respirators, employee training, medical surveillance, signs and recordkeeping.

EFFECTIVE DATE: This standard is effective September 4, 1978.

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SUPPLEMENTARY INFORMATION: This permanent occupational safety and health standard is issued pursuant to sections 6(b) and 8(c) of the Occupational Safety and Health Act of 1970 (the Act) (84 Stat. 1593, 1599; 29 U.S.C. 655, 657), the Secretary of Labor's Order No. 8-76 (41 FR 25059) and Title 29, Code of Federal Regulations (CFR) Part 1911. It amends Part 1910 of 29 CFR by adding a new § 1910.1043 entitled "Cotton dust," and by adding a footnote to the reference to "cotton dust (law)" in Table Z-1 of § 1910.1000 stating "this standard applies in cotton yarn manufacturing until compliance with § 1910.1043 (d) and (e) is achieved." For reasons set forth below, the new standard does not apply to the growing and harvesting of cotton, the ginning of cotton, maritime operations, the handling or processing of woven or knitted materials, or the handling or processing of washed cotton. In order to assure that affected employers and employees will be informed of the existence of these provisions and that employers affected are given an opportunity to familiarize themselves and their employees with the existence of new requirements, the effective date of the new § 1910.1043 will be September 4, 1978. To provide continued protection for employees until the provisions of the new standard become effective, the requirements pertaining to cotton dust currently contained in § 1910.1000 Table Z-1 remain in full force and effect until § 1910.1043 becomes effective. In yarn manufacturing the requirements pertaining to cotton dust currently contained in § 1910.1000 Table Z-1 remain in full force and effect until compliance with § 1910.1043 is achieved.

I. BACKGROUND

A. GENERAL

Cotton is commercially grown in at least nineteen states and is a major crop in fourteen. The states generally considered to be the largest producers of cotton are Texas, California, Mississippi and Arkansas. Between ten and thirteen million bales (480 lbs net wet) of cotton lint are produced annually in the United States.

The cotton industry of the United States can be divided into eleven major processes: (1) harvesting; (2) ginning; (3) warehousing and compressing of cotton lint; (4) classing and marketing of cotton lint; (5) yarn manufacturing using cotton lint; (6) fabric manufacturing using cotton yarn; (7) reclaiming and marketing of textile manufacturing waste; (8) delintering of cottonseed; (9) marketing and converting of linters; (10) reclaiming and marketing of gin motes; and (11) batting, yarn and felt manufacturing using waste cotton fibers and byproducts. Within each of these major processes there are various stages, distinct work procedures and methods of operation.

Less than 15 percent of the cotton crop is grown in the southeastern states where the textile industry is concentrated. Thus, a large proportion of the crop is transported long distances to domestic mills or to ports for export. Most of the crop is harvested and ginned in the fall and early winter; it is processed by domestic and foreign mills on a year round basis. Hence, storage and transportation are major elements of the entire cotton industry.

The cottonseed is separated from the cotton lint at the gin. From the gin, most cottonseed moves into oilseed processing. Cotton linters, the short fibrous material adhering to cotton seed after ginning, are removed from the seed by machines before the seeds are crushed.

Gin motes are a byproduct of the cotton ginning process. They consist of lint cotton waste useable for its fiber content. Gin motes may be cleaned and baled at the gin, usually in a building separate from the gin plant, or sold in loose form to mote cleaning plants which pick up motes in bins or trailers at regular intervals. At the mote cleaning plant the loose gin motes and the unclean baled gin motes are cleaned or reclaimed, baled and stored pending sale to the spinning trade for use in yarn and to the felting trade for use in batting and felting.

After ginning most cotton lint moves into a warehouse for storage or a compress for hydraulic pressing to higher density pending shipment to cotton mills or ports for export. Bales are initially sampled at the gin or warehouse for classification by the United States Department of Agriculture under the United States Cotton Standard Act (7 U.S.C. 51-65). Bales are usually resampled by warehousemen and reclassed by merchants or shippers one or more additional times as they move through marketing channels. Transportation, storing and sampling of cotton all involve employee exposure to cotton dust primarily as a result of cotton dust being generated into the atmosphere by the handling of cotton.

Subsequent operations involve cleaning and refining of cotton lint into yarns for knitting or weaving; or processing of waste cotton fibers into byproducts such as upholstered furniture, batting and felting for bedding, furniture and thermal insulation.

The proportion of cotton to synthetic fiber in textile goods has generally decreased in recent years with the advent of newer texturizing processes for synthetic fibers. However, processed cotton has certain desirable properties which make it unlikely that complete substitution by synthetic fibers would ever occur. Among these are its properties of moisture absorbancy, coolness, softness, ready adaptability into leisure fabrics such as denim and corduroy, and economy of use. In addition, substitution of synthetic fibers results in increased use of petroleum products and other forms of energy.

B. HISTORY OF THE REGULATION

(1) Early developments. Substantial improvement in working conditions in

the cotton textile industry did not occur until well into the twentieth century. The most important early improvements came in England as a result of legislative acts requiring medical inspection of workplaces, compulsory reporting of industrial diseases and compensation of diseased and disabled workers. In 1942 a compensation scheme was introduced in England as a means of implementing the Factory Act of 1937 and associated legislation which for the first time recognized byssinosis as an occupational disease.

In 1964 the American Conference of Governmental Industrial Hygienists (ACGIH) placed cotton dust on its tentative list of threshold limit values (TLV), and in 1966 they adopted a 1000 $\mu g/m^3$ of total cotton dust as their recommended value for exposure. This TLV was based upon the work of Roach and Schilling in the Lancashire cotton mills. Exposure to cotton dust was not regulated in the United States until 1968, when the Secretary of Labor under the Walsh-Healey Act (41 U.S.C. 35 et seq.), promulgated the 1968 ACGIH list of Threshold Limit Values which included for "Cotton dust (raw)" the limit of 1000 $\mu g/m^3$. This standard was subsequently adopted as an established Federal standard under section 6(a) of the Occupational Safety and Health Act of 1970. In 1972, the British Occupational Hygiene Society (BOHS) published a report, largely based upon Molyneux and Berry's "Correlation of Cotton Dust Exposure with the Prevalence of Respiratory Symptoms," recommending a new standard of 500 $\mu g/m^3$ less "fly"; the term fly meaning dust particles removed by a 2-mm wire screen. In addition, in 1972, on the basis of BOHS and others, a revision of the ACGIH TLV was recommended that would measure respirable dust rather than "total dust". In 1974, a TLV of 200 $\mu g/m^3$ of cotton dust as measured by the vertical elutriator was adopted by ACGIH.

On September 26, 1974, pursuant to section 20(a)(3) of the Act, the Director of the National Institute for Occupational Safety and Health (NIOSH) submitted to the Secretary of Labor a criteria document which contained NIOSH's recommendations for a new cotton dust standard.

On December 27, 1974, OSHA published an Advance Notice of Proposed Rulemaking (39 FR 44769) requesting that interested persons submit their views on specific issues relating to cotton dust, particularly the NIOSH Criteria Document.

Thereafter, in January 1975, the Textile Worker's Union of America filed a petition with the Secretary urging the Secretary to propose a modified standard for occupational exposure to cotton dust, setting an exposure limit of 100 $\mu g/m^3$. They were joined in this petition by the North Carolina Public Interest Research Group.

(2) The Proposal. On December 28, 1976, OSHA published a proposal to revise the existing standard for occupational exposure to cotton dust (41 FR 56498). The proposal called for a permissible exposure limit of 200 $\mu g/m^3$ of vertical elutriated cotton dust for all segments of the cotton industry.

The proposal allowed 90 days for interested parties to submit written comments, views, and arguments and announced that an informal public hearing for the submission of oral testimony would begin on April 5, 1977. Additional hearing dates were set by notice published March 15, 1977 (42 FR 14134). There were 263 comments and 109 notices of intent to appear at the hearings.

(3) The Hearing. The OSHA rulemaking hearing was conducted in Washington, D.C. from April 5–8, May 2–6, and 16–17; in Greenville, Mississippi on April 12; and in Lubbock, Texas on May 10–12, 1977.

Numerous persons appeared at the hearings as witnesses. Among the witnesses were large corporate and small business employers, manufacturers, representatives from the affected workforce, experts in every relevant field including physicians, scientists, statisticians, economists, industrial hygienists, representatives from agriculture, and other interested parties. Public participation was representative of virtually the entire "cotton community." The written and oral testimony of all participants was made part of the rulemaking record. The hearing record was originally scheduled to close on July 17, 1977, but at the request of several parties it was kept open until September 2, 1977 (42 FR 39120).

(4) Environmental Impact Statement. In conjunction with the development of the proposed standard, OSHA prepared a draft environmental impact statement. The draft environmental impact statement was published in the FEDERAL REGISTER (41 FR 56498) on December 28, 1976, along with the proposal.

Prior to the promulgation of this final standard, OSHA prepared a final environmental impact statement (FEIS) in accordance with 29 CFR 1999.5. Notice of the availability of the FEIS was published by the Environmental Protection Agency on December 30, 1977 (42 FR 65263).

(5) The Record. This final cotton dust standard is based on careful consideration of the entire record in this proceeding, including materials relied on in the proposal and the record of the informal rulemaking hearing including the transcript, exhibits prehearing and post-hearing written comments and briefs. Copies of the official list of hearing exhibits, comments, and notices of intent to appear at the hearing can be obtained from the Docket Office, Docket No. H-052, Room 56212, U.S. Department of Labor, Third Street and Constitution Avenue NW., Washington, D.C. 20210.

II. PERTINENT LEGAL AUTHORITY

The primary purpose of the Act is to assure so far as possible safe and healthful working conditions for every working man and woman. One means prescribed by Congress to achieve this goal is the authority vested in the Secretary of Labor to set mandatory safety and health standards. The standards setting process under section 6 of the Act is an integral part of an occupational safety and health program in that the process permits the participation of interested parties in consideration of medical data, industrial processes and other factors relevant to the identification of hazards. Occupational safety and health standards mandate the requisite conduct or exposure level and provide a basis for ensuring the existence of safe and healthful workplaces.

The Act provides that:

> The Secretary, in promulgating standards dealing with toxic materials or harmful physical agents under this subsection, shall set the standard which most adequately assures, to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life.
>
> Development of standards under this subsection shall be based upon research, demonstrations, experiments, and such other information as may be appropriate. In addition to the attainment of the highest degree of health and safety protection for the employee, other considerations shall be the latest available scientific data in the field, the feasibility of the standards, and experience gained under this and other health and safety laws. (Section 6(b)(5)).

Sections 2(b) (5) and (6), 20, 21, 22, and 24 of the Act reflect Congress' recognition that conclusive medical or scientific evidence including causative factors, epidemiological studies or dose-response data may not exist for many toxic materials or harmful physical agents. Nevertheless, standards cannot be postponed because definitive medical or scientific evidence is not currently available. Indeed, while final standards are to be based on the best available evidence, the legislative history makes it clear that "it is not intended that the Secretary be paralyzed by debate surrounding diverse medical opinion." House Committee on Education and Labor, Report No. 91-1291, 91st Cong., 2d Session, p. 18 (1970). This Congressional judgment is

supported by the courts which have reviewed standards promulgated under the Act. In sustaining the standard for occupational exposure to vinyl chloride (29 CFR 1910.1017), the U.S. Court of Appeals for the Second Circuit stated that "It remains the duty of the Secretary to act to protect the working man, and to act even in circumstances where existing methodology or research is deficient. *Society of the Plastics Industry, Inc.* v. *Occupational Safety and Health Administration*, 509 F. 2d 1301, 1308 (2nd Cir. 1975), cert. den., sub. nom., *Firestone Plastic Co.* v. *United States Department of Labor*, 95 S. Ct. 1998, 4 L. Ed. 2d 482 (1975).

A similar rationale was applied by the U.S. Court of Appeals for the District of Columbia in reviewing the standard for occupational exposure to asbestos (29 CFR 1910.1001). The Court stated that:

> Some of the questions involved in the promulgation of these standards are on the frontiers of scientific knowledge, and consequently as to them insufficient data is presently available to make a fully informed factual determination. Decision-making must in that circumstance depend to a greater extent upon policy judgments and less upon purely factual judgments.

Industrial Union Department, AFL-CIO v. *Hodgson*, 499 F. 2d 467, 474 (D.C. Cir. 1974).

In setting standards, the Secretary is expressly required to consider the feasibility of the proposed standards. Senate Committee on Labor and Public Welfare, S. Rep. No. 91-1282, 91st Cong., 2d Sess., p. 58 (1970). Nevertheless, considerations of technological feasibility are not limited to devices already developed and in use. Standards may require improvements in existing technologies or require the development of new technology. *Society of Plastic Industry, Inc.* v. *Occupational Safety and Health Administration*, supra at 1309; *American Iron and Steel Institute* v. *Occupational Safety and Health Administration*, ——— F. 2d ——. (C.A.3, 1978) R., 3CCH ESHG Para 22637.

Where appropriate, the standards are required to include provisions for labels or other forms of warning to apprise employee of hazards, suitable protective equipment, control procedures, monitoring and measuring of employee exposure, employee access to the results of monitoring, and appropriate medical examinations. Standards may also prescribe record-keeping requirements where necessary or appropriate for enforcement of the Act or for developing information regarding occupational accidents and illnesses (section 8(c)). The permanent standard for cotton dust was developed on the basis of the above legal considerations.

III. Occupational Health Implications of Exposure to Cotton Dust

A. General

The preamble to the proposed standard for exposure to cotton dust, presented detailed scientific evidence demonstrating the health hazard to workers in the various cotton industries and the extent of that risk (41 FR 56498, Ex. 6 # 1, 2, 3, 7, 13, 14, 15, 16, 17, 18, 19, 20, 21, 42, 43, 44, 51, 54, 55). The provisions of the proposed standard were based on this evidence. Upon reviewing the complete body of data compiled in the record, including a thorough discussion of the underlying evidence, OSHA has determined that the basic conclusions advanced in the proposed regulations have withstood critical scrutiny by the public, the cotton industry and the scientific community. Accordingly, the evidence set forth in detail in the preamble to the proposal, will not be repeated here.

The overwhelming scientific evidence in the record supports the finding that cotton dust produces adverse health effects among cotton workers (Ex. 1, Ex. 11, Ex. 13, Ex. 19, Ex. 12, Ex. 38, d). The disorders range from an acute reaction manifested by a depression of pulmonary function indicators, or by subjective symptoms such as chest-tightness, shortness of breath, or cough, to a stage characteristic of chronic obstructive pulmonary disease which is often disabling (Ex. 48, P.1; Ex. 6. # 17, 20, 21, 42, 43, 57, 54, 56). The chronic stages of cotton dust induced respiratory disease are, as a clinical entity, similar to chronic bronchitis or emphysema (Ex. 41, p. 5). While gaps exist in the understanding of the etiology of respiratory disease caused by cotton dust and their progression from acute to chronic stages, the evidence in the record supports the fundamental connection between cotton dust and various respiratory disorders in both the textile and the non-textile industries (Ex. 1, Ex. 38d, Ex 11).

Byssinosis is the specific respiratory disease attributable to the action of cotton dust on the respiratory passages. The essential hallmark of byssinosis is the Monday phenomenon, the cyclic disorder characterized by cough, breathlessness or tightness of the chest experienced on the first day of the work week (Ex. 48, p. 1). The Schilling grading scheme for byssinosis discussed in the proposal inherently reflects the differences in duration and degree of the Monday morning symptoms (41 FR 56498).

In addition to the familiar subjective symptoms, objective measurements sometimes indicate the presence of airways obstruction (Ex. 41, pp. 8-10). Pulmonary function measurements such as Forced Expiratory Volume in one second (FEV_1) or Forced Vital Capacity (FVC) are frequently used to indicate deviation from normal breathing. As the NIOSH statement (Ex. 38, a) introduced at the hearing explains:

> Pooled data on groups of workers with byssinosis consistently show a strong association between byssinosis and drops in expiratory flow rates on Monday . . ., both also clearly attributable to cotton dust exposure. Among individuals, however, it has been observed repeatedly that those with Monday chest tightness do not necessarily show a drop in FEV_1, and conversely, individuals with clearcut drops in Monday FEV_1 will not necessarily have a history of byssinosis.

There is further testimony that, if large groups of workers are surveyed for subjective symptoms and for pulmonary function changes, approximately the same proportion exhibit both subjective symptoms and decrements of pulmonary function (Ex. 38d). OSHA also agrees with MIOSH that "characteristic respiratory symptoms and drops in flow rates are useful epidemiologic and clinical tools and are highly associated with cotton dust concentration (Ex. 38d)."

From the description of its manifestations, it is clear that byssinosis represents a constellation of respiratory effects (Ex. 38 d, Ex. 11, Ex. 6, Ex. 1, Ex. 12, Ex. 13). These effects range from acute to chronic and from reversible to disabling, and may be described by diverse terminology, such as reactor state or chronic bronchitis, but these respiratory diseases have been conclusively shown to be causally related to exposure to cotton dust (Ex. 1, Ex. 11, Ex. 38 a, b, d).

B. Chronic Obstructive Pulmonary Disease

It was the overwhelming opinion of the medical experts testifying at the hearings that byssinosis can develop into chronic obstructive pulmonary disease which is, in most cases, irreversible and disabling (Ex. 38d, Ex. 11, Ex. 41, Ex. 46). The preamble to the proposal describes Grade 3 byssinosis as follows:

> "In this advanced stage the clinical picture often becomes confused, as the chronic disease process is neither well understood nor well defined. Workers frequently manifest symptoms consistent with chronic bronchitis and emphysema. This stage is generally considered to be irreversible, with work in dusty atmospheres becoming extremely difficult or impossible. The rate at which a worker progresses to this stage, if at all, depends upon the amount of the causative agent contained in the dust inhaled, and the susceptibility of the individual."

In human terms, the affected worker frequently loses the ability to function normally on or off the job. Members of the Carolina Brown Lung Association (CBLA) testified at the hearing that the respiratory disease contracted in the textile mills typically resulted

in premature retirement often after futile and painful attempts to continue on the job (Ex. 51, Ex. 54).

Testimony pointed out that several terms were being used interchangeably to describe the final clinical stage of cotton dust induced respiratory disease. These include: grade 3 byssinosis, chronic or advanced byssinosis, chronic obstructive lung disease, or the specific names of chronic obstructive pulmonary diseases (i.e. chronic bronchitis and emphysema). Among textile workers "brown lung" appears to be a synonym for disabling respiratory disease. In that sense, Dr. Russell Harley's suggestion that the term chronic obstructive pulmonary disease (COPD) constituted a generally accepted clinical definition of chronic lung disease that described the clinical end product of cotton dust induced lung disease without becoming entangled in definitions of preceding stages of the disease has merit (Ex. 41, p. 2).

The record strongly indicates that chronic bronchitis, one form of COPD, is prevalent among byssinotics (Ex. 6, #8, 17, 19, 20). Data on groups of workers with byssinosis consistently demonstrate a strong association between byssinosis and drops in expiratory flow rates on Monday and chronic cough and phlegm (bronchitis), which are both also clearly related to cotton dust exposure (Ex. 6, #17, Ex. 38d, Ex. 6, #22, 23, 25; Ex. 11). Chronic bronchitis which is not specifically related to cotton dust exposure has also been found to be far more common among cotton textile workers than among workers in mills processing only synthetic fibers (Ex. 6, #17, 21, 22, 23, 24, 32).

Since exposure to environmental pollutants such as cigarette smoke has also been identified as a causative agent of COPD, parties to the hearings representing industry argued that COPD caused by cotton dust was a minor fraction of COPD prevalence among textile workers and that most was caused by smoking (Ex. 41, p. 6; Ex. 47, #18; Ex. 46, p. 1). Dr. Mario Battigelli, testifying on behalf of the American Textile Manufacturers Institute (ATMI), stated that the background level of chronic bronchitis among the general population, estimated by him at between 10 and 40%, easily explained the observed high prevalence of chronic bronchitis, 3-50%, among cotton textile workers (Ex. 48, p. 8). It should be noted that Dr. Battigelli's estimate of background chronic bronchitis, based as it is on autopsy studies, is not comparable with other studies of relatively healthy men and women (Ex. 6, #17).

OSHA recognizes that smoking is an influential variable in the production of COPD among cotton workers (Ex. 6). Indeed, the co-existence of exposure to cotton dust and exposure to cigarette smoke has been shown to result in increased risk of COPD (Ex. 41, p. 6; Ex. 47, Ref. #18; Ex. 46, p. 1; Ex. 38 d; Ex. 11). However, persuasive evidence demonstrates that the cigarette smoking variable, rather than overwhelming the cotton dust variable, is merely related to it. Indeed, there are no studies in the literature attributing the high prevalence of respiratory disease found among cotton workers primarily to smoking, or, in other words, there is no documentation for Dr. Battigelli's statement. Conversely, where the relationship between exposure to cotton dust and smoking has been explored scientifically, substantial evidence characterizes the increased risk from smoking to be additive or multiplicative to the risk due to exposure to cotton dust (Ex. 11). Dr. Arend Bouhuys of Yale University, a pre-eminent authority on pulmonary function, described the relationship as follows (Ex. 11, p. 16):

> . . . in our statistical analysis of symptom prevalence among large numbers of cotton textile workers and appropriate controls we found that, for all symptoms, work in textile mills was by far the largest factor in determining the prevalence of respiratory symptoms. For shortness of breath, mill work was the only significant variable. For chronic cough, sputum and wheezing, cigarette smoking was an additional important variable, but of lesser degree of significance than work in the mills. In other studies where similar analyses have been performed, cigarette smoking has also emerged as a contributing factor to chronic symptoms. But in these studies no control group was considered at the same time, so that the preponderant effect of exposure to dust in mills (in comparison with the absence of such exposure among persons not employed in textile mills) could not be assessed. It is also important to point out that shortness of breath is an important factor in disability among cotton textile workers, and that this symptom was not significantly affected by smoking. Although it should be considered an additional risk for cotton textile workers, the extent of the risk of smoking is not clearly different for cotton workers and for others not employed in the cotton textile industry. In fact, we found that the effects of cotton dust exposure and of smoking on chronic lung function loss were additive, and there is no indication in our data for any synergism between the two exposures with respect to long-term lung function.

Other evidence is consistent with Dr. Bouhuys' findings. One particularly striking feature is the high prevalence of respiratory disease among women textile workers who have never smoked (Ex. 6, #17, p. 427). Finally, it has generally been found that bronchitis prevalence is proportional to level of dust wherever this parameter has been studied.

Undoubtedly some COPD exists in the cotton worker population which is independent of exposure to cotton dust. Neither Dr. Battigelli's figures nor morbidity data from a study done in a Colorado community appear to shed light on the normal state of employee health. However, Merchant's control population consisting of textile workers in wool and synthetic industries provides a reasonable estimate of the prevalence of bronchitis among textile workers not exposed to cotton dust (Ex. 6, #17). These levels of chronic bronchitis varied from 2-3% to approximately 12% depending upon age, sex and smoking habit (Ex. 6, #17). As Merchant's work made clear, compared to these controls, workers exposed to cotton dust exhibit a significantly greater prevalence of chronic bronchitis, i.e. 24% (Ex. 6 #43, p. 173); in this study, not only cotton dust exposure but also smoking (Ex. 6, #43) and age (Ex. 6, #17 p. 427) were found to be determinants of chronic bronchitis frequency and severity.

One new study (Ex. 124) introduced into the record shed further light on the relationship of background respiratory disease to the prevalance of COPD among textile workers. In a community study of chronic impairment among active and retired textile mill workers 45 years and older in a South Carolina town, Bouhuys compared the local mill population with matched controls in another southern town and in two similar northern towns. Although the study did not attempt to establish a baseline for worker COPD morbidity, it was designed to exclude interference from non-cotton dust induced lung disease among the study population. Bouhuys found, on the basis of respiratory questionnaires, that textile workers of both sexes, irrespective of age, demonstrated significant excesses of chronic cough, wheezing, dyspnea and other symptoms, in comparison to controls. Work in textile mills was found to be the prime variable affecting symptom prevalence. The results of lung function testing showed that both male and female textile workers suffered significantly greater loss of pulmonary function than controls and, thus, were at greater risk of chronic lung disease. Based on a definition of disability as an FEV_1 level of 1.2 liters or less, textile workers suffered respiratory disability at triple the rate found in controls.

Dr. Bouhuys' criterion for disablement is a conservative one, since an FEV_1 of 1.2 liter or less even for a very old person is a small fraction of the pulmonary performance of a normal lung (Ex. 11, p. 18). Yet Dr. Bouhuys estimates that approximately 35,000 employed and retired textile workers are currently disabled (Ex. 11, p. 1). This projection assumes that 200,000 are currently at risk in the mills and approximately 235,000 retired textile workers are no longer employed in the industry. Although some estimates of the prevalence of chronic disease have been presented in various studies, the

Bouhuys estimate constitutes the only evaluation of chronic health effects for the entire active and retired textile worker population. While retired workers will not be protected by this standard their health status is relevant in evaluating the risk of cotton dust exposure. During the hearings, dozens of CBLA members, all post textile workers, gave personal accounts of the physical, social, and economic hardship resulting from COPD (Ex. 54).

When all degrees of chronic bronchitis are examined, not just the disabling form, Merchant found an overall prevalence for chronic bronchitis of 24% to 12% for employed textile workers. In both the Merchant (Ex. 6. #17, 43) studies and the Bouhuys study mentioned above, control populations were found to have significantly less chronic bronchitis. It is generally believed that this chronic bronchitis is irreversible. There was some testimony, particularly by Dr. Russell Harley on behalf of the ATMI, that early stages of advanced respiratory disease may be reversible usually upon removal from cotton dust exposure (Ex. 41). However, it appears from the evidence, that the usual course for most workers is to continue to suffer gradual deterioration which soon becomes irreversible.

Virtualy all medical witnesses, including those from industry, testified that prevention of chronic obstructive pulmonary disease should be pursued vigorously by the cotton industry (Ex. 11, 12, 13, 19, 38, 41, 42, 46, 47, 48). OSHA believes that the cotton dust standard, including provisions for engineering controls to limit dust exposures, respirators, and medical surveillance to indentify pulmonary deterioration, should accomplish this goal.

In addition to the evidence of COPD among textile workers, the record contains data identifying COPD generally among non-textile employees exposed to cotton dust including garnetters, (Ex. 38, Appendix F) waste utilization and gin employees (Ex. 19) (Ex. 38. Appendix E). The development of COPD has been less well defined for the various non-textile industries than it is for textiles. Several reasons may account for the difference. In the ginning industry employee exposure is seasonal for a major segment of the population. As Dr. M. A. El Batawi of the World Health Organization testified, based on his studies of Egyptian gin workers, the seasonal factor delays the onset of byssinosis by allowing recovery of workers' lungs during the time of removal from exposure (Ex. 19). Thus, fewer workers with lower grades of byssinosis proceed to the chronic stage than would be found in workplaces subjecting employees to continuous exposure. The significance of seasonality on the health effects in gin employees is discussed in the preamble to the separate standard for ginning. In addition, the development of COPD in even non-seasonal operations may be affected to some extent by varying compositions of dust.

C. ACUTE HEALTH EFFECTS

Since byssinosis represents a continuum of disease, it is axiomatic that the chronic, irreversible stage is preceeded, at the opposite end of the disease progression, by an acute, relatively mild, apparently reversible stage of disease. This earliest stage is characterized by varying subjective and/or objective symptoms that may not at first unduly alarm the victim or present a physician with clear-cut diagnosis. Nevertheless this early developmental stage of respiratory disease is a pathological state, and OSHA finds persuasive the arguments for adopting a cotton dust regulation which protects workers from the acute consequences of cotton dust exposure. Evidence in the record convinces OSHA that it is necessary to protect the many thousands of workers who exhibit grade 1/2 byssinosis or non-repeatable or relatively small declines (e.g. 50 ml or 5%) (Ex. 6, #1) in Forced Expiratory Volume or Forced Vital Capacity. Witnesses on behalf of ATMI testified that these acute symptoms were not cause for concern. However, industry testimony failed to disprove the significance of these acute effects as symptoms of respiratory disease which in many cases with further exposure progresses inevitably to the chronic irreversible respiratory diseases associated with cotton dust exposure (Ex. 11, p. 17). OSHA believes that grade 1/2 byssinosis and associated pulmonary function decrements are significant health effects in themselves and should be prevented in so far as possible.

Acute objective and subjective symptoms caused by inhalation of cotton dust often are precursors of chronic obstructive pulmonary disease (Ex. 6, #17, #43). Grade 1/2 byssinotics as a group exhibit lower FEV_1 values, greater pulmonary function decrement over the shift and higher prevalences of bronchitis than normal workers (Ex. 6, #1). It is not unreasonable to conclude that the diminished state of health of grade 1/2 byssinotics is a stage of the progressive development with prolonged exposure to cotton dust to an ultimate, irreversible respiratory disease. As Dr. Bouhuys explained: (Ex. 11, p. 17)

"Cotton and other textile workers are at risk of acute as well as chronic respiratory symptoms and lung function loss. There is little or no doubt that both are caused by exposure to respirable dust in cotton textile factories. Although the progression from repeated acute insults to the chronic disease has not been traced with certainty, there is no good evidence against—and much evidence for—such a train of events. It seems most logical to define byssinosis as a dust-induced disease with initial acute responses followed by a stage of chronic lung disease characterized by chronic airway obstruction. This definition is implicit in the description of the clinical stages of byssinosis given by Schilling many years ago."

Since workers with occasional chest tightness often do not understand the connection between the work environment and the symptoms, they are likely to remain on the job in continuing dust exposure. (Ex. 6, #1, Ex. 11, Ex. 54). There is evidence that grade 1/2 byssinotics may revert to a normal state of health if exposure to cotton dust is discontinued; nevertheless, OSHA is convinced by the evidence in the record that those many workers who will grow progressively worse must be identified and protected.

IV. PERMISSIBLE EXPOSURE LIMITS

(A) GENERAL CONSIDERATIONS

OSHA believes that the causal relationship between exposure to cotton dust and the development of byssinosis and other respiratory diseases has been clearly established. It follows, then, that the most important step in reducing the risk of cotton dust induced respiratory disease is to reduce employee exposure to cotton dust (Ex. 6, #1, 19, 30, 51, 55, 57, 58; Ex. 124).

At the same time, OSHA recognizes that cotton dust is a heterogeneous mixture containing an as yet unidentified active agent or agents. Cotton dust is defined in this standard as "dust present during the handling or processing of cotton which may contain a mixture of substances including ground-up plant matter, fiber, bacteria, fungi, soil, pesticides, non-cotton plant matter and other contaminants which may have accumulated during the growing, harvesting and subsequent processing or storage periods." As the preamble to the proposal states, the relative proportion of these substances in "cotton dust" can vary depending upon the type of plant, harvesting and storage methods, and cleaning operations, both at the gin and in subsequent processing (41 FR 56503).

Some parties at the hearings argued that the standard should be delayed until an active agent was isolated (e.g. Ex. 65a). OSHA has concluded that the weight of evidence in the record requires the implementation of a standard based on "cotton dust," as broadly defined, to all the segments within the scope of the cotton industry in order to prevent further and widespread development of acute and chronic respiratory disease including irreversible and disabling chronic obstructive pulmonary disease. The continuing scientific debate over the identity of the specific agent does not de-

tract from the conclusion that "cotton dust," as defined and regulated by this standard, has been shown to cause a constellation of respiratory illnesses (Ex. 11, Ex. 38a, d; Ex. 124; Ex. 6, #1, 30, 17, 31, 32, 33, 34, 51, 55, 57, 58). Protection of employees cannot await resolution of all the points of scientific debate.

First, there are likely to be multiple agents involved in the acute response and there is no certainty that these agents are responsible for the long-term damage to the lungs after exposure. Several witnesses with long involvement in the search for the active agent expressed the belief that multiple agents and pathways were probably at work in the development of byssinosis.

Second, as witnesses who have been involved in early efforts in byssinosis research point out, claims that the causative agent has been identified have been periodically advanced over the years and, so far, is often cast aside. There is no assurance that the agent will be discovered in a reasonably short time period. On the other hand, numerous studies have correlated exposure to cotton dust to the prevalence of byssinosis. Thus, several witnesses conclude that, at the present time, there is no basis for any programs of prevention and control of byssinosis other than those based on prevention of exposure to respirable cotton dust. Indeed, removal of lint-free respirable dust from the air cotton workers breathe is both feasible and offers effective protection against any toxic agents present in the dust.

Detailed analyses of the physical and chemical composition of cotton dust from different sources and subjected to all the variables of processing, from harvest to recycling, were the basis for the testimony of numerous industry organizations attempting to justify establishing a standard on other than the lint-free respirable fraction of cotton dust as proposed.

OSHA recognizes that in the absence of detailed dose-response data, the risk to workers from cotton dust generated in many segments of the non-textile industry cannot be precisely defined. To the extent that evidence of the physical composition of the dust, such as that presented by Dr. Wakelyn, corroborates medical evidence that the nature of cotton dust generated by a certain process is less hazardous to worker health than that encountered in a textile mill, OSHA has accounted for the mitigation of risk by applying a higher exposure limit. However, the value of dust composition data alone is extremely limited in assigning risk to various concentrations of dust. Where medical research is available, physical and chemical data is less acceptable.

B. PARTICLE SIZE

In the proposal, cotton dust concentration was defined in terms of the vertical elutriator cotton dust sampler. The final standard has severed the description of cotton dust from the type of device or method of measurement employed for reasons which are more fully discussed in the section on monitoring. It should be noted that a critical feature of the vertical elutriator's design, the size cut-off at 15 microns, has been preserved in the final standard by setting the permissible exposure limits in terms of particles 15 microns or less in size. Although there is some debate in the record over the appropriate size designation for "respirable" particles that range from less than 5 to 20 microns, the most persuasive testimony supports continued reliance on particles sized 15 microns and less as the basis for estimating the risk of byssinosis. Thus, studies measuring lint-free respirable dust (15 μg and less) appear to more closely correlate dust concentration with physiological response than do studies measuring broader particle distributions (Ex. 6, #41, 51, 66). It could be argued that the studies by Roach and Schilling measuring "fine dust" (less than $=7\mu$) with the horizontal elutriator provide a good comparison in terms of correlations with studies made with the vertical elutriator (e.g. Ex. 1, pp. 53-60). The vertical elutriator, however, has generally replaced the horizontal elutriator as the instrument of choice for cotton dust epidemiology. One explanation for this may be the belief that deposition of larger particles than are normally considered to be respirable, in the strict sense (i.e. greater than approximately 7μ), in the trachea and upper respiratory regions may play some role in the acute response often characterized by constriction of these larger airways.

In summary, until the causative agents contained in cotton dust are isolated in the laboratory and their effects verified with rigorous epidemiological testing, the proven hazard to cotton workers from lint-free respirable cotton dust must be controlled, even without a complete understanding of the etiology of byssinosis. The risk of byssinosis has been correlated with exposure to cotton dust by numerous researchers. Consequently, OSHA maintains that worker protection from exposure to cotton dust can be assured by controlling lint-free respirable cotton dust and that this conclusion is overwhelmingly supported by the evidence in the record.

C. PERMISSIBLE EXPOSURE LIMITS

The standard provides that no employee in the textile industry shall be exposed to greater than 200 $\mu g/m^3$ of lint-free respirable cotton dust averaged over an eight-hour work shift, unless these employees are engaged in slashing or weaving, in which case they shall not be exposed to greater than 750 $\mu g/m^3$ of lint-free respirable cotton dust averaged over an eight-hour work shift. In all other industries where employees are exposed to cotton dust, no employee shall be exposed to greater than 500 $\mu g/m^3$ of lint-free respirable cotton dust averaged over an eight-hour work shift.

Whereas numerous foreign and American studies have provided a basis for determining the prevalence of byssinosis in the textile industry, the work by Merchant et al. (Ex. 6 #51) represents the most thorough and objective evaluation of byssinosis prevalence in the United States textile industry. The Merchant study covering approximately 3000 workers employed in 8 cotton and cotton-synthetic blend mills and control synthetic and wool mills found a strong linear association between the prevalence of byssinosis and the concentration of lint-free respirable dust as measured by a vertical elutriator. In cotton preparation and yarn areas, untreated cotton was shown to produce byssinosis prevalences of 7 percent (all grades) at 100 $\mu g/m^3$, 13 percent at 200 $\mu g/m^3$ and 26 percent at 500 $\mu g/m^3$. For blend mills, the prevalences were markedly lower, however, dust levels from blend mills were considerably lower than equivalent areas of pure cotton mills. In weaving, the dose-response curve was shifted downward. According to this data, there is essentially no byssinosis prevalence at 200 $\mu g/m^3$, 5 percent at 500 $\mu g/m^3$ and 15 percent at 1.0 $\mu g/m^3$. The lower prevalence of byssinosis is attributed to the inclusion of inert sizing in the dust measured.

Although the Merchant study (actually approximately 15 papers published over several years (Ex. 6 #17, 20, 43, 51, 61, 110; TR 241-2)) has been part of the scientific literature since the early 1970's, considerable critical comment was addressed to it at the hearings. Most adverse testimony either directly challenged the methods and the findings of the Merchant study, or indirectly questioned Merchant's prevalence finding by introducing independent evidence of lower prevalences in the textile industry.

Dr. Hans Weill presented a 1976 study (Ex. 13A) sponsored by ATMI of 486 cotton textile workers measuring prevalence of byssinosis, of lung fuction impairment, and post-shift function decline. The study design intended to examine the effects of past high, intermediate and no exposure on workers in three separate mills which were originally thought to be currently achieving low levels of dust (200-500 $\mu g/m^3$) or, in other words, mills with very low doses. Pooling of the data gathered for all mills indicated a sig-

nificant relationship between exposure and prevalence of byssinosis, with a prominent increase in risk associated with exposure at or above 500 $\mu g/m^3$. However, analysis of the data by mill, which showed most of the employees classified as byssinotics to be located in one mill, whereas the prevalence in the two remaining mills was barely above that found in the control mill, suggested the influence of a "mill factor" in the study. Statistical analysis indicated that the effect of employment in a given mill was present even beyond the effects of smoking rates, proportion of preparation workers per mill and, most importantly, level of current dust exposure. Thus, the term "mill factor" implies that byssinosis prevalence depends primarily on factors other than exposure to cotton dust itself, and, presumably, two mills with equal employee dust exposure could pose drastically different risks to employees.

Since the mill effect has not been a previously noticed or reported factor in assessing the risk of cotton dust exposure, the validity of the finding was contested by several parties. The authors of the Weill study themselves conceded that some more commonly understood effects may explain their findings.

Thus the authors stated:

> One may still be primarily detecting a dust level effect since the exposures in this mill were heavily weighted to the high group with no one falling into the low exposure category. It is possible, therefore, that the mill effect is masking the dose-response relationship. (Ex. 13A, p. 23)

In addition, unmeasured variables such as grade and blend of cotton processed, dust control equipment in place, or speed of processing could explain the results of the study (Ex. 13A, pp. 23-24).

Some testimony amplified the possibility of the mill effect being explicable in terms of the quantity of dust rather than the quality of dust. As Dr. John Peters of the Harvard School of Public Health pointed out in reference to the three exposure categories used, namely under 0.2 mg/m^3, 0.2 to 0.5 mg/m^3 and over 0.5 mg/m^3:

> The high exposure category (0.5 mg/m^3 and higher) is much higher in Plant II than the high exposure category in Plant I and Plant III. Inspection of Table 5 of the report reveals that for Mill I and Mill III there were several exposure measurements that exceeded 0.5 mg/m^3 only slightly, whereas, in Plant II, those exceeding 0.5 exceeded this level significantly. One of their points from the study was that there is a mill effect over and above the exposure effect. This might well have only reflected the fact that byssinotics largely occurred in Plant II, and the very heavy exposure occurred in Plant II. Had a fourth exposure category been chosen (say over 1.0 mg) several of the byssinotics in Plant II would have been in this category. This further gradation in byssinosis prevalence could explain the so-called mill effect. (Ex. 143, Appendix A.)

Dr. Peters, using raw data obtained from Dr. Weill, calculated that if 4 exposure categories are used the prevalence of byssinosis correlates well with dust level (Ex. 143, Appendix A).

There are other possible explanations for the mill factor which relates risk to exposure. Dr. Weill made it clear that his study was originally designed to study the effect of past exposure on current respiratory responses to low levels of cotton dust (Ex. 13A, p. 1). Dr. Weill had found that pulmonary function results indicated excessive annual decline in lung function related to length of cotton mill work and post-shift declines that were greater in cotton than in synthetic fiber workers, although the differences were only of marginal significance. However, there is testimony that length of exposure might also explain the mill effect "since a statistically significant relationship is seen between length of exposure and the FEV_1 and FVC percent of predicted in two of the mills which have had previous cotton dust exposure, one at a low level presumably around 0.2 and 0.5 mg and the other at a higher level (Ex. 143, App. A, p. 7)." The past exposure in the mill with high prevalence of byssinosis had been higher than in the other two mills which had processed cotton for only 4 and 10 years.

A second survey (Ex. 39) of the prevalence of byssinosis and respiratory symptoms was conducted in three mills by Dr. W. K. C. Morgan at the request of Burlington Industries. Morgan found only 3 employees out of a volunteer population of 720 in 2 mills (0.4%) admitting to byssinotic symptoms on a questionnaire. One worker among 240 in a control mill complained of similar symptoms. No difference between the prevalence and severity of shortness of breath was found to exist between the three mills, and only small differences were found in comparing maximal FEV_1 and FVC decrements (5% or greater) between cotton and synthetic fiber workers in the card room and other jobs. When FEV_1 and FVC readings of all workers were compared to predicted values, a significant number of subjects had reduced ventilatory capacity, with somewhat greater proportions of affected workers in the two cotton mills. The participation rate in the pulmonary function measurements, however, was 60-65%, an unusually low percentage. The results of the survey, in general, found no significant byssinosis hazard in these three mills.

Although Dr. Morgan did not have knowledge of dust levels at the time of his study, dust level data was supplied by Burlington Industries for the record at the request of the Agency (Ex. 43). Dust levels in the 3 plants surveyed ranged from below 200 $\mu g/m^3$ to 1040 $\mu g/m^3$ in the card rooms with mean redings of approximately 250 $\mu g/m^3$. As in the case of many mills selected for the Weill Study, the mills in the Morgan survey were characterized by relatively low dust exposure and a worker population which had been part of an ongoing medical surveillance program.

Empirical data based on the experience of industry's ongoing medical surveillance programs provided a second source of evidence at the hearings. Data gathered by industrial physicians from 3 of the major textile companies was presented separately and collectively in a compilation of statistics representing the medical surveillance programs of several member companies (Ex. 47). Collection and pooling of data was conducted by ATMI (TR 1917).

Dr. Harold Imbus of Burlington Industries compared results from an initial medical survey of employees in 19 company plants during 1970 and improved results collected in 1976 (Ex. 47). In the original screening, 460 out of 10,133 (4.5%) of all exposed employees complained of subjective symptoms of grades ½ to 2 byssinosis on a questionnaire compared to 136 out of 12,519 (1.0%) in 1976. The percentage of subjects demonstrating a 10% or greater post-shift decrement in FEV_1, also declined from 18% to 7.4% during the period. Dr. Imbus credited significant reduction in dust levels as one of the reasons for the improvement in medical statistics. Other factors included selective placement and transfer of employees, use of respirators by susceptible employees, and institution of counselling and the ongoing functioning of the medical surveillance program itself.

Among 5,458 Cone Mill employees surveyed in 1973, 199 provided questionnaire responses associated with grades ½ and 1 byssinosis (Ex. 46). However, among workers employed in opening through roving, 105 out of 655 or 16% exhibited symptoms of byssinosis. High levels of bronchitis were also reported. Dust measurement at the 14 plants were not taken at the time of the survey.

A 1973 report of West Point Pepperell's initial survey (Ex. 42) indicated that 124 workers out of 9,181 responded positively to a questionnaire, and 11.8% of those tested for decrement in FEV_1 over the shift showed a 10% or greater decline. When only opening through roving was considered, a 5.3% prevalence of byssinosis was observed. Dr. Whitworth's testimony assigned a 5.4% prevalence rate to a worker population typically exposed to dust levels ranging from 500 to 750 $\mu g/m^3$.

The results of the initial surveys of the 3 companies detailed above were

pooled by ATMI with similar data collected from other textile manufacturing companies with medical programs (Ex. 47; TR 1849). The resulting pooled prevalence data purported to cover questionnaire surveys of 41,283 employees. Overall prevalence, all grades, was reported to be 1.79% with 4.3% prevalence reported for opening through roving. The highest prevalence in preparation, 11.3% was associated with areas with dust measurements known to be greater than 500 $\mu g/m^3$, whereas only a 4.41% prevalence was reported for dust levels equal to or below 500 $\mu g/m^3$. The prevalence of pulmonary function decrements (FEV_1 10%) equalled 8.5% overall and, in the case of preparation areas, 22.65% and 9.02% for areas assigned dust levels greater than 500 $\mu g/m^3$ or below respectively. Dr. Imbus used the ATMI findings of 737 cases of byssinosis among 41,283 employees to project the total number of byssinotic employees for a total population exposed to raw cotton dust estimated by ATMI to be 150,000 (Ex. 47). Approximately 2,700 employees would be expected to have subjective symptoms of byssinosis if the 1.79% prevalence rate were applied to the population figure given by industry.

Research Triangle Institute also calculated the number of workers who could be expected to exhibit classical byssinotic symptoms (Ex. 6, #76, pp. I-4 to I-5, pp. III-1 to III-23). Applying the dose-response relationships for yarn preparation and slashing-weaving workers developed by Merchant et al. to worker population figures published by the U.S. Department of Labor, RTI estimated that approximately 37,794 textile employees exhibited all grades of byssinosis at current dust levels. The divergence between the ATMI and RTI prevalence estimates is difficult to reconcile without examining the underlying data.

Questioning of Dr. Imbus by Dr. Merchant raised serious questions about the validity of the ATMI data (TR 1916-23). Dr. Merchant pointed out that the number of preparation workers gathered from published studies by Dr. Imbus and by Dr. Martin (340) and presented in testimony by Dr. Whitworth (approximately 90), equalled a greater number for the 3 companies involved (430) than the total number given by ATMI (369) for all the companies contributing to the pool (TR 1916-17). The number of Burlington, Cone and West Point Pepperrell employees in the worker pool constituted approximately two-thirds of the total 41,000 workers. Thus, according to the ATMI data, no other worker in opening through roving in any other mill which pooled data had byssinosis in any grade. In yarn preparation there are also unaccountable discrepancies between the prevalences of byssinosis published for 2 major companies, 26% for Burlington and 16% for Cone Mills, and that presented by ATMI for the pooled group, 4.3% (TR 1917-18). Comparison with byssinosis prevalences and percent pulmonary function decrement in preparation reported in outside studies indicated even greater disparities. In addition, Dr. Merchant pointed out an unexplained 15% excess of workers reported as showing a 10% decrement in pulmonary function over those reporting byssinosis (TR 1919). Many investigators have reported a rough equivalency between these figures. Finally, because the ATMI material was broken down roughly into two broad exposure categories, no dose-response relationships could be drawn from the data.

As no party responsible for assembling and pooling the industry data was available at the hearings to explain the ATMI survey, questions directed to the sources and validity of the survey went unanswered. An ATMI response to OSHA's request for fuller detail on its pooling resulted in the production of material (Addendum #6A), that by its nature prevented any further critical analysis and failed to dispel the doubt cast on the data by NIOSH cross-examination. Thus, the ATMI data could be accorded only limited significance in the analysis of the health risk at various levels of cotton dust exposure.

Some witnessess from industry disputed the validity of using the Merchant Study to any extent to represent the hazard in the textile industry from exposure to cotton dust.

Dr. Moon Suh of Burlington Industries reviewing the Merchant data from a statistical approach argued that what he characterized as methodological errors invalidated the study for the purpose of predicting byssinosis prevalence of the average textile population (Ex. 55). Dr. Suh argues that build-in biases in location and age of plants, length of exposure, and quality of cotton processed inflated prevalence data, that the use of a probit model to analyze the data is statistically unjustified, and that grouping of some data points, exclusion of others, use of median dust levels rather than mean, and "other irregularities" invalidate the study for predictive purposes. In comparison, Dr. Suh presented a dose-response study of a Burlington population sampled in 1971 and analyzed without the errors he attributed to the Merchant study, which projected 2.2% byssinosis prevalence at zero dust level (attributable to false-positive responses). Dr. Suh's study found a byssinosis prevalence of 2.8% at 100 $\mu g/m^3$, 3.5% at 200 $\mu g/m^3$, and 6.0% at 500 $\mu g/m^3$. Dr. Suh concluded that neither the Merchant study nor any other in the literature provided an adequate statistical basis for establishing a numerical exposure limit.

A review of the extensive testimony on the methodology and analysis employed in the Merchant study, its criticism by Dr. Suh, and rebuttal, convinces OSHA that the Merchant study provides a reliable assessment of health risk to cotton textile workers from cotton dust. OSHA notes that the Merchant data has been published and subject to peer review for several years without any major reported challenge to its basic soundness (TR 264-5). The only exception is Dr. Suh's categorical criticism of the study (Ex. 55).

There are admittedly some weaknesses in the Merchant data, for example, the small size of the populations in certain statistical cells and, consequently, the weakness of some correlation coefficients. Mr. Ken Busch of NIOSH who helped in the analysis admitted that he would have made some modification in the handling of the data (TR 1407, 1415-17). On the other hand, Dr. Merchant, Mr. Busch (TR 1376-9, 1381-5, 1408-9, 1411-14) and, also to some extent, Dr. Kaye Kilburn (TR 259-60, 288-9), responded convincingly to several charges of error by Dr. Suh with respect to use of probit analysis (TR 1378-80, 1382-84, 1404-5), the discarding of data points (TR 1411-14), and use of median and mean values for dust measurements (TR 1013-14, 1219, 1400-3).

Upon reviewing the testimony, OSHA believes much of the disagreement over the statistical propriety of Merchant's field study to represent extremely fine points in academic argument (e.g. TR 1417). In support of this point, OSHA refers to Dr. Suh's Tenet:

> To begin, I must point out that the entire byssinosis issue still remains to be only a statistical paradox in the complete absence of any definitive science on the diagnosis and pathogenesis or proven knowledge of the responsible chemical components. Indeed, we are still playing the game of numbers based strictly on isolated incidences or yet-to-be-found laws of probability at best (Ex. 55, p. 1).

Contrary to Dr. Suh's view, an evaluation of the methodology of this massive survey of thousands of textile workers shows the Merchant study to have been based on sound statistical ground. OSHA recognizes other evidence in the record to support in great measure the Merchant findings of health hazard in the cotton textile industry.

On the contrary, OSHA finds serious problems with the ATMI evidence contradicting the Merchant data. Dr. Suh's survey introduced with his testimony demonstrates remarkably low prevalences of byssinosis compared

with the findings of other studies or work done in Burlington Mills (e.g. Ex. 6, #18). The study contains neither objective pulmonary function data nor dust sampling which can be compared with typical vertical elutriator measurements.

Following up on one of Dr. Suh's points, Dr. Solomon Hersh testifying for ATMI (Ex. 58), claimed that the designers of the Merchant study failed to discount false-positive responses. Dr. Hersh used calculated values of natural response to readjust Merchant's probit analysis and thus explain the phenomenon of 2.2% response at zero dust concentrations as that attributable to false-positive responses. However, it is noted that the 2.2% byssinosis prevalence at zero dust level was not projected by the Merchant analysis in which the probit curve actually passed through the origin. The only false-positive value used in the Merchant study was derived from empirical rather than fabricated data (TR 1009). Merchant in his testimony, described false-positives as positive responses to the questionnaire by control workers in wool and synthetic mills, and quantified the level as 0.75%. In fact, according to testimony by Mr. Busch, when modification of the probit analysis suggested by Dr. Hersh is used with actual rather than assumed false-positive values, there is no significant differences in the result of the probit curves (TR 1412–15).

On the issue of the representativeness of data, OSHA shares the concern of parties to the hearing. The Agency is aware of the numerous factors advanced in the record which can influence the dose-response relationship and, therefore, the findings of a study. For example, it appears that several of the mills surveyed by Dr. Weill and Dr. Morgan reflect the improvements in health effects which could be achieved when low dust exposure is combined with a medical surveillance program. Indeed, the data from these studies centering on the low end of the dose-response curve support the feasibility of the basic requirements of the standard and the reduction in health hazard at low dust exposure. The Weill study in particular demonstrates the difficulties inherent in analyzing epidemiological data collected using a mixture of either very clean or very dusty mills.

OSHA concludes that the Merchant study has withstood challenge to its design and analysis. The study has been discussed in great length in the criteria document, the proposal and this final standard and by numerous experts in the medical and scientific field, and has been relied upon by the ACGIH in recommending an exposure limit. It has been shown to be a sound indicator of the response of U.S. textile workers to cotton dust. Even while cautioning against extrapolation of his data to industry-wide prevalence, Dr. Merchant stated, "In developing dose-response curves, however, we did get a good distribution of the dust over a large variety of dust measurements and we did find striking dose-response relationships (TR 1031–32)." OSHA concludes that the dose-response data of Merchant, supported by numerous other studies discussed in the preamble to the proposal, is the best available evidence and that it provides the Agency with sufficient evidence upon which to take action to protect the health of workers in the cotton industry. In reaching this conclusion, OSHA has given appropriately little weight to ATMI's pooled data which has been advanced as "representative" of the health situation in the textile industry. In this regard it is noted that the record contains no explanation for the dramatic inconsistencies between published industry data and the private calculations made by ATMI.

1. The Textile Industry

OSHA believes, based on its evaluation of all these studies and evidence analyzed in the preamble to the proposal, that strong justification supports the setting of a 200 $\mu g/m^3$ standard for the yarn preparation areas of the cotton textile industry. In reaching this decision, OSHA believes that the rationale for proposing a 200 $\mu g/m^3$ level for the textile industry is still valid. OSHA's reasoning as expressed in the proposal will therefore be briefly summarized.

After reviewing the scientific literature, OSHA stated that most cotton dust research demonstrated "a decrease in disease prevalence with decrease in dust levels." The evidence indicated that exposure to cotton dust was harmful over a wide range of exposures, and, in fact, recent studies showed a higher prevalence of byssinosis at even lower dust levels than evidenced by earlier studies.

The discussion in the proposal traced the advance in cotton dust research from the pioneering work of Roach and Schilling to the studies done in the U.S. by Merchant et al. and others using the vertical elutriator. It was clear from these studies that cotton dust produced significant health effects at low levels of exposure.

In setting a permissible exposure limit, the proposal evaluated the 200 $\mu g/m^3$ option as follows:

> The American Conference of Governmental Industrial Hygienists, while recognizing that there was no readily measurable limit that would eliminate byssinosis, in 1974 established a Threshold Limit Value for cotton dust of 200 $\mu g/m^3$ of dust composed of fibers less than 15 μm. According to the work of Merchant, there would be a predicted prevalence of byssinosis of 12.7 percent (all grades) and 3 percent (Grade two) at 200 $\mu g/m^3$; other investigators have found lower prevalence at these levels, but nevertheless conclude that some byssinosis will exist. (41 FR 56504)

The proposal went on to support the 200 $\mu g/m^3$ level as follows:

> In the criteria document NIOSH stated that there is "no environmental limit of cotton dust that will prevent all adverse effects on workers health." Merchant et al. found cases of byssinosis associated with dust levels as low as 50 $\mu g/m^3$. Statistical treatment of the data of Molyneux and Berry, and Imbus and Suh, indicates some prevalence of byssinosis at exposure levels so low as to be effectively zero. These data cannot be ignored. Accordingly, OSHA recognizes the absence of any known "safe level of exposure." When it proposes a permissible exposure limit of 200 $\mu g/m^3$ of respirable cotton dust, which it considers to be the "lowest feasible," OSHA feels that considerable reduction of work place exposure accompanied by a substantial decrease in byssinosis, particularly the chronic variety, can be achieved at this level.

After discussing the impact technological feasibility played in determining an appropriate level, OSHA concluded "on the basis of all the currently available evidence, 200 $\mu g/m^3$ of respirable cotton dust appears to represent the lowest feasible level, and to provide substantial protection for employees exposed to cotton dust."

During the course of the hearing, NIOSH articulated its support for the 200 $\mu g/m^3$ permissible exposure limit. The NIOSH testimony reasoned as follows:

> Byssinosis prevalence relative to respirable dust is reviewed in detail in the NIOSH criteria document (Appendix 1). Four investigators, Roach, Merchant, Lammers, and Imbus reported a total of 98 cases of byssinosis below 0.25 mg/m^3 fly-free dust. Extrapolation of dose-response curves suggests there is no clear threshold of response to cotton dust. Probit analysis of the dose-response data of Merchant et at. shows an associated byssinosis prevalence of 6.5% at a median dust level of 0.1 mg/m^3, 12.7% mg/m^3 at 0.2 mg/m^3, and 25% at 0.5 mg/m^3. These prevalence figures are compatible with those observed by Molyneaux and Berry in their extensive study of the British cotton yarn industry. Merchant et al. also observed increased bronchitis prevalence among preparation and yarn workers exposed at dust levels below 0.1 mg/m^3. Decrements in expiratory flow rates also followed a linear dose-response curve and objectively confirm the observations of respiratory symptoms. Thus, three parameters of adverse health effects—byssinosis prevalence, bronchitis prevalence, and decrement in expiratory flow rates—were observed at median dust levels below 0.2 mg/m^3 in preparation and yarn areas of cotton and cotton/blend mills (Ex. 38a).

NIOSH concluded that "an environmental standard not exceeding 0.2 $\mu g/m^3$ is required in these areas (preparation and yarn areas)." Other parties also testified in support of the 200 $\mu g/m^3$ exposure limit, including many scientific and medical experts. Upon ana-

lyzing the underlying evidence and the discussion presented during the hearing, OSHA believes that the proposed 200 $\mu g/m^3$ permissible exposure limit in the cotton textile industry is the appropriate level for this final standard.

Industry witnesses, however, have testified that a 500 $\mu g/m^3$ permissible exposure limit is equally protective. OSHA believes that the analysis advanced in the preamble to the proposed cotton dust standard rejecting an exposure limit above 200 $\mu g/m^3$ to be still valid. In discussing the 500 $\mu g/m^3$ option, the proposal recognized that:

> Some investigators have shown a "low" prevalence of byssinosis, generally less than 10 percent (all grades) and less than two percent grade 2, following exposure at estimated dust concentration levels of 500 $\mu g/m^3$ respirable dust (6, 54, 55). It appears, however, that 500 $\mu g/m^3$ respirable dust (as measured by the vertical elutriator) is roughly equivalent to the current 1,000 $\mu g/m^3$ total dust, a level viewed as inadequate in the above discussion.
>
> Merchant concludes that 500 $\mu g/m^3$ respirable dust would result in a prevalence of byssinosis of over 25 percent (all grades). Therefore, though 500 $\mu g/m^3$ may be somewhat protective in a number of cotton processing operations, OSHA considers the work of Merchant and others as indicating that it is not sufficiently protective in many operations. (41 FR 56504)

Admittedly other studies have found lower prevalences at 200 $\mu g/m^3$, but these studies have also shown that 200 $\mu g/m^3$ represents a significant reduction in the number of affected workers.

In addition, there are other factors that support the analysis and conclusion presented in the proposal. Initially, it is noteworthy that very little new scientific evidence was introduced at the hearings in support of a 500 $\mu g/m^3$ exposure level. None of the industry studies, except for the Weill study, correlate prevalence of byssinosis or pulmonary function reactivity with dust levels. The Weill study, which is discussed at length above, demonstrates another general difficulty in interpreting the findings of industry surveys: the mill population and often the mills selected have been the subject of dust control, health protection programs, and production changes which would all tend to mitigate the employee response to subjective and objective measurements. This trend toward improved work environments and medical surveillance has been particularly pronounced among the industry's largest companies that have conducted studies or make their mills available for study. Natural production trends, particularly the addition of new technology in opening, carding and to some extent, spinning, have been shown to reduce dust exposure. In addition, the blending of synthetic fibers with cotton has repeatedly been shown to reduce dust levels and, concomitantly, disease prevalence (e.g. Ex. 64, p. 2). Blending is increasingly common in modern manufacturing. For an industry leader, such as Burlington Industries, the combination of reduced dust levels from improved ventilation for reasons of health and production, medical surveillance, medical removal, counseling and respirator usage, have significantly reduced the prevalence of byssinosis and pulmonary effects (Ex. 47). It is notable that the dust levels in 66% of Burlington work areas measure below 500 $\mu g/m^3$ and 28% are below 200 $\mu g/m^3$ (Ex. 47, p. 3). It is not surprising, therefore, that data gathered from a worker population which has enjoyed conditions approaching those mandated for the entire industry by this final standard show a marked improvement in worker health.

Besides positive improvements in the environment, industry estimates of byssinosis prevalence appear to be understated due to other factors, particularly where worker responses are recorded. Some of the disparity between subjectively and objectively obtained health statistics has been attributed to employee reluctance or confusion when confronted with an employer-administered medical questionnaire. There is ample evidence that care must be taken to assure the employee that he will not be prejudiced by his responses. This is especially true when employees fear that forced transfer or early retirement might follow from their test results.

For all these reasons, the subjective health data provided by those few leading companies whose testimony can be documented has not been viewed by the Agency as adequate to rebut the objective health evidence in the record. On the contrary, the success of some of these companies in reducing exposure to levels approximating those in this final standard and concomitantly reducing adverse health effects supports the appropriateness of the level chosen. OSHA believes that the final standard should be especially feasible for those few exemplary companies who have acted to reduce the hazards to the respiratory health of their workers. However, for those many companies who have not succeeded in reducing exposures, the standard must be applied to assure adequate worker protection.

At the other end of the range of exposure limits, OSHA has also rejected a 100 $\mu g/m^3$ or lower limit advocated by the Amalgamated Clothing and Textile Workers Union and the Carolina Brown Lung Association. OSHA does not consider the prevalence of byssinosis predicted for the 200 μg level to be acceptable. On the contrary, OSHA recognizes that a 13% prevalence of byssinosis, including 3% grade 2 byssinosis could be expected at this level (Ex. 6, #51). However, the standard requires implementation of medical surveillance, employee training, work practices, and other protective provisions in textile mills which should provide additional protection beyond that afforded by the 200 $\mu g/m^3$ exposure limit. The record indicates that while medical surveillance is not fool-proof in detecting cotton dust induced health effects, a properly managed program should identify affected workers well before the onset of chronic obstructive pulmonary disease. In addition, the Merchant study predicts only a 3% prevalence of grade 2 byssinosis at 200 $\mu g/m^3$ which should be greatly reduced by medical screening.

Several large companies, notably Burlington Industries, have demonstrated the ability to operate reasonably efficient and effective medical surveillance programs in the mill environment. In addition, despite the absence of medical removal provisions from this standard, several industrial medical directors have testified to the existence of medical transfer practices in their companies. There is further evidence that the maximum number of workers effected at 200 $\mu g/m^3$ is not beyond the capacity of a typical plant to move those affected to a low exposure area. For all these reasons, OSHA believes that the prevalence of byssinosis should be significantly reduced and development of chronic obstructive pulmonary disease should be halted if cotton dust exposures are limited to 200 $\mu g/m^3$ in primary textile processing.

In the preamble to the proposed cotton dust standard, OSHA conceded that there was no known safe level of exposure. However, the other factors, particularly technological feasibility, which supported OSHA's decision to propose a 200 $\mu g/m^3$ exposure limit still pertain (41 FR 56505). In addition, a level much below 200 $\mu g/m^3$ would run into serious interference from background dust levels. Dr. Y. Y. Hammad of Tulane University, testifying on behalf of OSHA, stated:

> "The average concentration of particulate matter in urban and suburban areas varies between 58 $\mu g/m^3$ to 180 $\mu g/m^3$ depending on size and activity of the city. The majority of suspended particulate matter in ambient air is usually less than 200 um. Pasceri reported that respirable fraction in ambient air constitutes about 60% of the total suspended particulate matter. In other words, the background airborne particles are within the particle size range collected by the vertical elutriator in concentrations close to the proposed standard of 200 $\mu g/m^3$" (Ex. 14, pp. 9-10).

Implementation of 100 ug/m^3 or a lower level would appear to require efficient filtration in outside make-up air entering the ventilation system of many areas (Ex. 14, p. 10). The report

of the Research Triangle Institute (Ex. 16, #76), combined with the testimony of representatives of the ventilation industry (Ex. 69), indicate that achieving 100 $\mu g/m^3$ is not within the technological capabilities of the industry. The subject is discussed further in the section on technological feasibility. On the other hand, evidence in the record demonstrates the successful reduction in byssinosis prevalence under operating conditions at the 200 $\mu g/m^3$ level of exposure and in combination with proper medical and administrative controls (e.g. Ex. 40; Ex. 13A).

OSHA has determined that the evidence in the record does not support the application of separate exposure limits for each discrete operation within the cotton textile industry. Dose-response relationships in the record have included data on workers employed in all major departments of the textile mill. These dose-response data and prevalences reported in isolated studies indicate that significant risk exists for workers in job assignments well down the processing chain from yarn preparation. Nevertheless, industry witnesses have advocated a higher exposure level for "downstream" manufacturing processes, particularly spinning (Ex. 160). There is some evidence of low prevalence rates among spinners (Ex. 1, pp. 144–5), usually associated with low dust exposures or situations where the spinning room has been physically separated from the yarn preparation areas (Ex. 6, #17). On the other hand, in addition to the Merchant dose-response data, independent investigators have found high prevalences of byssinosis among spinners: 29%, Bouhuys et al. (Ex. 6, #24); 12%, Zuskin et al. (Ex. 6, #2); 25–29%, Molyneaux and Tombleson (Ex. 6, #2); 10%, Schrag and Gullett. Also, Bouhuys' data on the prevalence of chronic disablement among active and retired workers demonstrates that spinners are as likely as carders to experience excess risk of lung function loss (Ex. 124, p.7, 13). This evidence of a significant hazard to health of spinners and employees in contiguous departments outweighs the speculation that the unidentified active agent(s) are processed out or are not as toxic in operations past roving. Further, it appears that a mill configuration which allows cards and spinning frames to share space or air circulation systems could result in contamination of the spinning employees' environment (Ex. 6, #17). Accordingly OSHA does not find adequate evidence in the record to warrant raising the allowable dust concentrations to which spinners, winders, twisters, spoolers, et al. can be exposed.

In the special case of slashing and weaving, OSHA does believe adequate evidence exists in the record to permit a higher exposure limit without sacrificing employee safety. First, the Merchant study includes a separate dose-response relationship for weavers (Ex. 6, #51). According to a probit analysis of this data, the byssinosis prevalence is zero at 200 $\mu g/m^3$, 5% at 500 $\mu g/m^3$, 10% at 750 $\mu g/m^3$ and 14% at 1000 $\mu g/m^3$. Other independent studies have supported the Merchant findings of markedly reduced symptoms of byssinosis in the weaving areas (Ex. 6, #14; Ex. 6, #18).

Second, the dust in the atmosphere of a typical weaving room has been demonstrated to be composed primarily of sizing materials, usually starch or polyvinyl alcohol (Ex. 6, #51; Ex. 47). Dust measurements taken in prior processing stages and in weaving show a gradual decrease in dust levels up to slashing where the dust concentrations increase conspicuously (Ex. 38, Appendix 1, Fig. 1). The rise is generally attributed to the addition of sizing. Microscopic photography confirms the dominance of sizing particles in relation to lint and dust on a typical filter (Ex. 59, 59a). Several witnesses testifying at the request of OSHA (Ex., TR 460) and industry (Ex. 59, 108) have stated that the presence of sizing would tend to dilute the cotton dust in the environment and, therefore, allow for a greater permissible exposure. No evidence suggests any adverse relationship between inert sizing matter at the concentration permitted and adverse health effects.

Third, the evidence in the record supports the conclusion that engineering dust controls in weaving may not be feasible even with massive expenditures by the industry (Ex. 4168; TR 2393; Ex. 60, pp. 18–19). Unlike other textile equipment, looms have not been fitted with local exhaust ventilation equipment for improved production or health reasons (Ex. 60, p. 15). The nature of the loom requires access by the tender (Ex. 60) which makes the enclosure of the mechanism very difficult. Because of the need to exhaust large quantities of air across the loom and through the floor, an expert in dust control technology have predicted that massive reorientation of the mill would be required (Ex. 60, pp. 14–16). For these reasons, RTI estimated the capital costs to comply with the 200 $\mu g/m^3$ standard to be $1.3 billion.

Of course, the Agency does not view the economic and technological feasibility of reducing dust exposure in a vacuum. It is primarily concerned with the health of weavers, and the record supports the conclusion that a permissible exposure limit of 750 $\mu g/m^3$ will provide weavers as safe an environment as their co-workers in other textile operations exposed to 200 $\mu g/m^3$. In addition, OSHA agrees with the reasoning of the North Carolina Department of Labor (Ex. 108, p. 3) that optimal worker protection would be served by concentrating the textile industry's technical and economic resources on achieving 200 $\mu g/m^3$ in yarn manufacturing as rapidly as feasible, rather than diverting substantial resources to eliminating dust exposure in weaving.

The authors of the merchant study suggest that 750 $\mu g/m^3$ is a "reasonably safe level of cotton dust exposure in slashing and weaving areas (Ex. a6, #55, p. 229)." At that dust level prevalence of all grades of byssinosis is equal to approximately 10% compared to approximately 13% at 200 $\mu g/m^3$ in carding. However, dust measurements made in the Merchant study were expressed in terms of median values. While comparative data demonstrates the virtual identity of mean and median dust values at the 200 $\mu g/m^3$ level, the values diverge at higher dust concentrations. Thus, a median dust concentration of 750 $\mu g/m^3$ correlates with a higher prevalence of byssinosis than does a mean dust concentration of 750 $\mu g/m^3$. From this data OSHA concludes that a 750 $\mu g/m^3$ mean dust permissible exposure limit in weaving areas would correspond to a disease prevalence below 10%. Furthermore, the Merchant recommendation for a permissible exposure limit in weaving was contingent on provision for periodic medical testing of workers (e.g. Ex. 6, #51), a contingency which has been incorporated in the final cotton dust standard.

2. Non-Textile Industries

The approach taken in this final standard to regulating the various non-textile segments of the cotton industry is to apply a single 500 $\mu g/m^3$ permissible exposure limit. This level is applicable to all non-textile industries including but not limited to: warehousing, compressing of cotton lint, classing and marketing, using cotton yarn (i.e., knitting), reclaiming and marketing of textile manufacturing waste, delinting of cottonseed, marketing and converting of linters, reclaiming and marketing of gin motes and batting, yarn felt manufacturing using waste cotton fibers and by products.

In the section on scope and application, the evidence supporting OSHA's decision to include under the standard all workplaces where workers are exposed to cotton dust is compiled and analyzed. These numerous studies evidence the existence of health problems similar to those observed in the textile industry whenever cotton dust has been studied. The arguments advanced by industry representatives that no hazard has been demonstrated in their workplaces ignore the overwhelming evidence of a serious hazard to workers from exposure to cotton dust regardless of where exposure is

encountered. OSHA finds significant the industry's failure to bring forth medical evidence controverting the studies in the record. Indeed, the survey for the warehousing industry presented by Dr. Martin Burman on behalf of the Cotton Warehousemen Association (Ex. 56) suggests that cotton-induced respiratory effects may be occurring with high frequency and, presumably, at relatively low dust levels at the compress. OSHA has concluded that cotton dust is a hazard to workers in all phases of cotton processing and that worker protection requires the application of a permissible exposure limit.

Setting an adequately protective environmental limit for the broad-ranging non-textile operations, however, requires the Agency to draw conclusions from data which do not totally lend themselves to specifying a safe exposure for each operation. The difficulty with the studies in the record is their lack of dose-response data. Without adequate data relating worker response to specific dust levels, the selection of permissible exposure limit is of necessity based largely on other considerations. The choice becomes much more complex if an attempt were made to set different exposure limits for each non-textile industry. There has been much criticism of using the dose-response data collected in textile mills to establish an exposure limit in the diverse segments outside the textile industry. OSHA agrees that without a better understanding of the dose-response effects in non-textile areas, the dose-response data appropriate for establishing an exact permissible exposure limit in textile manufacturing is not readily transferable in setting a precise level in any other industry segment.

In order to protect the workers employed in these widely varying workplaces, OSHA has adopted the most reasonable exposure level from the view point of worker protection in the face of a lack of definitive data. This approach is consistent with OSHA's mandate to assure a safe working environment. The Courts have agreed, stating:

"Some of the questions involved in the promulgation of these standards are on the frontiers of scientific knowledge, and consequently as to them insufficient data is presently available to make a fully informed factual determination. Decision-making must in that circumstance depend to a greater extent upon policy judgements than upon purely factual judgments." IUD v. Hodgson, 499. F. 2d 467, 474 (C.A.D.C., 1973); Accord; Synthetic Organic Chem. Mfrs. Assn, v. Brennen. 506 F. 2d 385, 390 (C.A. 3, 1974)).

In determining what level is reasonable, the Agency has relied upon its interpretation of all the evidence bearing on the health effects of cotton dust. Thus, there is much evidence to the effect that cotton dust affects workers in a similar manner; in other words, the toxic agent or agents in cotton dust appears in varying degrees wherever cotton dust is generated. Where adequate study has been done, cotton dust, like all toxic substances, exhibits a dose-response effect (Ex. 1, pp. 47–50). There is no reason to believe that cotton dust found in cotton seed oil mills or garnetting operations will not show a greater health hazard at higher dust exposures than at lower exposures when adequte data is generated. These considerations were the basis for the setting of a permissible exposure limit in the proposed standard. OSHA concludes that the record does not provide a basis for departing from this regulatory posture. It was argued that the extraordinarily high dust levels and lower adverse health effect demonstrated a lessened degree of toxicity in dust generated in non-textile operations (Ex. 93b; Ex. 97; Ex. 99b). OSHA notes the possibility that a reduced incidence of disease could be attributable to shortened periods of exposure due to the high turnover in non-textile workforces (e.g. Ex. 93, p. 6; Ex. 99b, pp. 6–10). Further, no complete study of the dose-response effects has been made and data cannot be complete when dust levels are so uniformly high.

Further, although the relationship between the lint free respirable fraction to total dust is not fully defined, OSHA has reason to believe that 500 $\mu g/m^3$ is roughly equivalent to 1.0 mg/m^3 measured by an OSHA personal sampler or high volume sampler in the spectrum of non-textile workplaces. Thus, the new standard is about as protective of health as the old standard, and OSHA would require much more definitive data than has been presented to justify a relaxation of protection.

OSHA also notes that Dr. Merchant testified that in his opinion a 500 $\mu g/m^3$ level was an appropriate one for the non-textile industry (Tr. 1298) and that other witnesses stated that a low level was needed in non-textile operations (Ex. 11, pp. 2–3, Tr. 189–90; Ex. 38a, p. 10). In selecting a 500 $\mu g/m^3$ permissible exposure limit, OSHA has set a level which is expected to provide an appropriate measure of protection.

OSHA has rejected a level lower than 500 $\mu g/m^3$ for several reasons. First, the dust levels recorded in most studies containing dust measurements present a general picture of extraordinarily high dust exposures in many workplaces with much less adverse health effects than the textile data would predict (e.g. Ex. 128 A, B; Ex. 99–C; Ex. 6, #68). It appears that 500 $\mu g/m^3$ exposure would very likely constitute a remarkable reduction in many workplaces.

Second, as in the case of the textile industry, the standard mandates medical surveillance, work practice controls, use of respirators, employee education and other provisions to protect employee health. These provisions should safeguard employees who are extremely sensitive even to less toxic levels of cotton dust.

Thirdly, RTI was doubtful of the technological feasibility of a 200 $\mu g/m^3$ standard in any non-textile segment (Ex: 16, pp. 21–26). The testimony presented at the hearings was not any more optimistic about industry's capacity to engineer to such a low level (Ex. 88b; Ex. 93f, j; Ex. 99d, e). On the other hand, there is considerable evidence that a 500 $\mu g/m^3$ exposure limit is feasible in all operations. Feasibility is discussed further in the section devoted to technological feasibility. Finally, there is no evidence that 500 $\mu g/m^3$ does not represent the safest feasible level in any one segment of the industry.

Thus, since there is no quantitative data establishing the precise margins of safety at various dust levels, OSHA has chosen the 500 $\mu g/m^3$ level on the basis of all the factors set out above. As a matter of policy OSHA has determined that it would not flirt with employee protection by setting too high an environmental level on the basis of non-definitive dose-response evidence.

In taking the approach that only an exemption would be appropriate, the industry failed to bring in any health evidence which would aid the Agency in determining whether a higher level represents an acceptable risk to the workforce. It appears inappropriate to allow the industry the benefit of a high-exposure limit until research is done, when worker health is threatened. OSHA is aware of projected studies of these operations, particularly by NIOSH, which might provide the Agency with further data. When these data are available, OSHA may have scientific justification for raising or lowering the permissible exposure limit. Until such data are available, however, OSHA concludes that a 500 $\mu g/m^3$ limit is both justified and necessary to protect worker health in the non-textile cotton industry.

V. Feasibility

In setting standards for toxic substances, the Secretary is required to give due regard to the question of feasibility. Section 6(b)(5) of the Act mandates that the Secretary shall set the standard which most adequately assure employees safety and health "to the extent feasible, on the basis of the best available evidence." Additionally, in the development of occupational safety and health standards, "considerations shall be the latest available scientific data in the field, the feasibility of the standards, and experience gained under this and other health and safety laws."

Accordingly, OSHA analyzes both the economic and technological feasibility of proposed standards. OSHA makes such analyses available to affected parties for comment and subsequent hearing prior to issuance of final rules, and invites the submission of other information on the economic impact and feasibility of proposed standards. In developing a standard for exposure to cotton dust, OSHA evaluated both the economic and technological feasibility of the standard on the basis of the entire rulemaking record, including the information developed by its own studies of the proposal and submissions by the public. On the basis of the best available evidence, therefore, OSHA has determined, as explained in detail below, that the permanent standard is both economically and technologically feasible.

A number of studies were done of both economic and technological feasibility considerations resulting from the cotton dust standard. The Research Triangle Institute Study (Ex. 16) contracted for by OSHA considered economic and technological factors for the entire cotton industry. Other studies submitted concentrated on particular industrial sectors affected by a cotton dust standard. In addition, feasibility was specifically considered in testimony at the hearings.

A. TECHNOLOGICAL CONSIDERATIONS

Upon reviewing all the studies and testimony in the record, OSHA concludes that the achievement of the permissible exposure limits established in the final cotton dust standard is technologically feasible. There is significant evidence that the textile industry can use its broad experience in lint and dust control to develop adequate engineering controls in those operations where reductions in dust levels have not been attempted. While adaptation of existing technology should be adequate to achieve compliance, the evolution of new technology has and is expected to continue to provide additional means of achieving lower dust levels and increasing production. In the non-textile industries where experience with dust control is more limited, the change in environmental limit from the proposed 200 $\mu g/m^3$ to 500 $\mu g/m^3$ has given the industry a goal which should be within its capability. Evidence demonstrates that, in both textile and non-textile industries, modification and adaptation of existing dust control systems should bring the vast majority of workplaces into compliance.

Throughout the course of the hearings, various control strategies to comply with the proposed permissible exposure limits set forth by RTI were discussed. Much of this testimony centered on the feasibility of achieving 200 $\mu g/m^3$ in the broad spectrum of cotton operations. The final standard establishes a permissible exposure limit of 200 $\mu g/m^3$ for the textile industry, except for slashing and weaving which are subject to a 750 $\mu g/m^3$ exposure level. All non-textile operations are subject to a 500 $\mu g/m^3$ permissible exposure limit under the final standard. In replacing a single level with multiple levels, OSHA considered testimony concerning available control strategies, data indicating the effects of exposure noticed at these levels, and the variability of observed effects depending upon the operation or process where exposures occurred.

From the view point of feasibility, OSHA believes that the concept of a multiple exposure level strategy brings achievement of these levels within the technological reach of all sectors of the industry. In support of its conclusions on feasibility, OSHA notes industry's own testimony which, in attempting to demonstrate the infeasibility of a uniform 200 $\mu g/m^3$ level, often supported the feasibility of alternative levels approximating those specified by the final standard. (National Cottonseed Producers Association, Parnell).

The RTI and other participant parties discussed four general methods of obtaining compliance with various exposure levels. These were ventilation (both general and local), modification or isolation of a process, work practices, and substitution (Ex. 1, Ex. 16, Ex. 17, Ex. 60). In certain non-textile segments of the industry and in parts of the textile process the adaptation of general methods of control appears to be needed to achieve compliance, and discussions of specific control techniques are not available. On the other hand, for some of the industry, notably early phases of textile processing, specific control techniques are not only feasible but are available and in place in several known facilities. This sophistication in textiles is understandable, since ventilation equipment has been designed over the decades to remove lint and visible particles in order to improve product quality or speed up production. While this equipment has been remarkably effective at removing a significant fraction of the respirable dust, only recently has emphasis been placed on removing respirable particulates from the workplace. This impetus, especially directed at improved filtration, has been successful in refining specific dust control techniques.

Upon evaluating the effects of cotton dust exposure, OSHA concluded that yarn preparation areas of the textile industry represent the most hazardous exposure and require implementation of a 200 $\mu g/m^3$ permissible exposure limit. OSHA also believes this is a technologically feasible level to obtain because of the textile industry's experience with dust control technology as evidenced by specific control measures described in the record.

A combination of specific control measures such as those described below, the adaptation and modification of general dust controls, and further utilization of technological developments which are already underway, should achieve compliance for the textile industry. However, whereas numerous commenters have stated that a 200 $\mu g/m^3$ level is feasible in all yarn preparation areas without requiring complete enclosure of equipment (Tr. 442), others maintain that it is only feasible to obtain a 200 $\mu g/m^3$ level in opening through roving (Ex. 160, p. 58). This narrower view of what is feasible is based on the industry's estimate of the difficulties involved in working with existing building structures, the configuration and positioning of equipment, and other factors peculiar to individual mills (Ex. 1, Ex. 16, Ex. 60). In general, industry has had less experience with specific controls past roving. OSHA recognizes these difficulties and further recognizes that increased effort may be necessary in some instances to achieve compliance with the exposure limit prescribed for the textile operation. Yet, the evidence in the record demonstrates the feasibility of adopting dust control principles, proven successful in other operations, to new stages of the process.

OSHA believes that achievement of a 500 $\mu g/m^3$ permissible exposure limit is technologically feasible for all non-textile segments of the cotton industry. Certain segments (e.g. warehousing and much of classing) are believed to be substantially in compliance. In other parts of the industry, however, OSHA recognizes that application of control technology has not advanced to the stage demonstrated for the textile industry. To some extent, the design of specific dust control equipment has lagged behind the growth of epidemiological and scientific knowledge of the diseases induced by cotton dust. In non-textfle operations in general, little attention has been paid to health problems. The failure to apply ventilation controls for health related reasons combined with the general inapplicability of sophisticated ventilation as a means to improved production leave parts of this industry with scanty experience regarding specific ventilation controls. In many instances, even general ventilation equipment has not been used and respirators have been regarded as the primary means for reducing employee exposure to cotton dust.

Despite these difficulties, OSHA has several reasons for its confidence that technology is well within the reach of

the entire industry. First, OSHA has established different exposure limits than proposed for broad sectors of the industry, including textile operations (e.g. weaving) and non-textile segments (e.g. cotton seed oil mills). In some cases, compliance can be achieved without the need for additional engineering controls; in others, industry studies confirmed feasibility if levels above 200 $\mu g/m^3$ were imposed.

Based upon its review of all the evidence in the record, OSHA concludes that achievement of the permissible exposure limits promulgated under this standard is technologically feasible for all operations, not just textiles. In reaching that conclusion, OSHA perceives the need for sectors of the industry to adapt available general dust control principles. OSHA would emphasize that compliance with the cotton dust standard by all segments of the industry depends upon the implementation of general principles of control and should not require "technology forcing" to achieve compliance.

OSHA, however, does recognize that implementation of the standard in certain operations, such as spinning, where the appplication of ventilation controls may involve unusual difficulties, significant innovation or indeed necessitate more than improvement in existing technology to achieve compliance, may be difficult. OSHA notes, however, industry's ability to seek alternative solutions to technological problems beyond those inherent in the adaptation of general control techniques.

This factor along with industry's experience with dust control systems leads OSHA to conclude that the permissible exposure limits are feasible. Testimony by the ACTWU maintains that technological advances based on automating and improving the manufacturing process have been preferred by employers to applying ventilation controls (ACTWU, p. 35). There is evidence that the textile industry has abated hazards due to cotton dust through process modification or machinery design changes in many cases where it has alleged environmental control techniques to be infeasible (ACTWU, p. 28).

As Dr. Parker Reist representing the Union stated (79c), production machinery now in use is old and was not designed with consideration for dust emission control. On the other hand, present dust emission controls, when considered with available modern machinery designs, incorporating higher production rates, labor savings, and improved product quality, will often result in lowering dust levels to within the range of the permissible exposure limit herein prescribed, while at the same time offering economic advantages. (79c). This is due in part to modern equipment being designed with built-in local exhaust ventilation controls as part of the equipment configuration. (open-end spinning, TR 2724). The impact of new technology in opening and carding is amply demonstrated. New technology may also become a significant factor in spinning, cotton seed delinting and wherever new equipment is explored. OSHA concludes that much can be done in the area of ventilation design on new equipment to achieve the permissible exposure limits.

1. General Methods of Dust Control. In assessing the evidence on technological feasibility, OSHA identified four general methods of control whose application should bring the vast majority of cotton workplaces into compliance with the permissible exposure established in this standard.

In the compliance scenarios developed below, a discussion of the general methods of control and the application of the basic methodolgy as presented by RTI, and other hearing participants is presented. The primary purpose for presenting the testimony in this manner is to demonstrate that control of cotton dust relies primarily upon general principles of dust control, and that where such principles have been applied, specific control strategies have evolved which have significantly reduced exposure to cotton dust.

(a) *Ventilation.* The primary method suggested by RTI for reducing exposure to cotton dust was installation of either general or local ventilation systems. Both new automatic equipment and older conventional machines require general room ventilation and local exhaust ventilation (TR 541). Thus, numerous commenters used these principles of environmental control (Ex. 60, Ex. 17), in projecting what can be done in some segments of the industry to bring exposures to within those levels herein prescribed. Indeed, this is what industry has done (Ex. 1, #127, Ex. 60, Ex. 37, 7), as is later discussed.

A. *General.* Testimony in the record indicates that with proper adjustment the central air-conditioning system found in many cotton processing facilities could constitute an effective dust control system. As Dr. David LeSourd of RTI stated, although air-conditioning systems were not designed to maintain low dust levels, with the installation of multi-stage filtration systems, they can become part of the cotton dust control strategy (Tr. 541). Both RTI and representatives of the Pneumafil Company agree that with two-stage filtration and air-washing built into the system, dust levels can be reduced to 500 $\mu g/m^3$ and with third stage filtration and washing, reduced to 200 $\mu g/m^3$ (Ex. 17). However, Robert Soule of Clayton Environmental consultants pointed out that, even when using supplementary filtration units within the air-conditioning system, a prudent approach to achievement of the levels herein prescribed would involve either decreasing the amount of air recirculated to the workroom or incorporating a more efficient dust collection system. (Ex. 17, p. 5). The recycling of air is an integral functioning of any air-conditioning system and as such, part of general ventilation system (Ex. 1, p. 72). In fact, a general principle to be applied is that the concentration of dusts within the work environment will equal the cleaned air dust concentration plus the ratio of the dust production rate divided by the recirculated air flow rate. With good dust capture or a large recirculating air flow rate the concentration of dust in the air which is returned to the workroom will eventually determine the concentration of dust in that space (Ex. 1, p. 72).

Implementation of this general control strategy should be facilitated by the fact that the cotton industry generally uses central air-conditioning systems as part of the ventilation system, not as dust control devices (Tr. 541), but because production requirements often demand both humidity and air-conditioning control (Ex. 16). Air is recirculated and supplemented by limited amounts of make-up air and discharged back into the workplace (Tr. 540). It also appears that if central air-conditioning systems are not utilized properly for dust control several dust problems can develop. Since large central air-conditioning systems tend to even out dust concentrations over the entire mill, increased levels may result from movement of dust from areas of high levels to those of lower levels or even by movement of dusts to areas of reduced air flow where they become trapped and concentrations build-up. One example of this phenomenon has been seen in classing areas (National Cotton Council Special Session on Cotton Dust, p. 31). Further, when air-conditioning systems by themselves are used as dust control devices, increased maintenance costs and impediment of performance often result. Reliance on the air conditioner for dust control means that dust must travel through the work area and into the breathing zones of the workers to reach the air-conditioner inlet usually located on one wall of the room. The fact that dust must be carried back through the breathing paths of workers makes it an inefficient method for dust reduction or removal. When the filtration stages mentioned above are added on and the system is adjusted, these problems should be eliminated.

The impact of various types of air cleaning equipment can be demon-

strated through measurements of dust levels in the work environment. Barr et al. surveyed several work environments and found that measurements ranged from 1000 to 260 $\mu g/m^3$ depending upon the type of air cleaning equipment used (Ex. 1, p. 73). This study clearly demonstrates that with high efficiency dust collection and removal, it is possible to achieve dust levels as low as 200 $\mu g/m^3$ in mills where complete recirculation of the interior air is required. The Barr study emphasized more than just the achievement of a particular level, it also denoted a "common sense" approach to reducing dust exposure in the workplace. Many times, installing a hood over a piece of machinery which is discharging dust throughout the workplace, or strategically collecting trash being discharged from operating machinery may be sufficient to reduce levels to the same extent provided by elaborate ventilation schemes. In fact, numerous commenters (Ex. 1, Ex. 17) maintained that significant reductions could be achieved simply by implementation of a program to maximize the effectiveness of existing dust control equipment.

B. *Local Exhaust Ventilation (LEV).* The capture and removal of dust from the air at its point of generation represents the most widespread and efficient method of dust control at the present time. It can be used in many circumstances where it is not now used to control exposure to cotton dust.

Local exhaust ventilation (LEV) is a control technique employing the following principles: capture of the contaminant as closely as possible to the point of generation; application of adequate air volumes for capture and transport of the contaminant; and selection of efficient filtration devices for collection of the contaminant (Ex. 16). Exhaust ventilation, as used for dust control, relies on providing a sufficiently high flow of air past a particle so that it abandons its state of rest for one of motion (Ex. 79c). In fact, both large materials (lint) and small materials (e.g. respirable dust) can be handled by local exhaust ventilation. Further, quantities of air required for ventilation would not be expected to depend on the concentration of dust in the air being removed, but rather on the dynamic properties of these particles in the air, (Ex. 16).

As the dust is collected by the appropriate capture devices it is transported to the filter media. As pointed out by Soule, some units which have coarse fabric bags which permit re-entry and are not effective against particulates 15 microns or smaller and therefore must incorporate a more efficient dust collection system (Ex. 17, p. 5). Hovan Hocutt of Pneumafil presented testimony on behalf of ATMI (Ex. 1, p. 127) and further elaborated on the "state of the art" which exists for air filtration systems. He concluded that coarse dust filters need additional refinement to obtain optimum filter efficiency, and a determination must be made of best design configuration and arrangement of coarse dust filters to achieve the most practical and economical addition of fine dust filters (Ex. 1, 127, p. 10). Like Soule, Hocutt also recommended that fine dust filters which are most practical for control of particulate sizes of 15 microns or less must be utilized and that the design and application of the filters to achieve dust control objectives may need further refinement (Ex. 17, Ex. 1, 127).

Newer production equipment is often designed with installation of additional dust collecting devices in mind (open end spinning frame), whereas some older equipment (traditional ring spinning) has made no allowance in design for installation of dust equipment. In general, while it appears that there exist standardized physical characteristics of dust collecting equipment, modification or alteration of certain equipment may be necessary for installation in some plants.

The dust-laden air is transported via ductwork to a filtration system. Three stages of filtration are currently employed: a primary, a secondary, and a tertiary filter system. The level of dust control effected is generally related to the number of filter stages through which the contaminated air passes. Both RTI and Pneumafil representatives maintain that by employing adequate dust capture devices, sufficient air volumes, and efficient single-stage filtration, dust levels in the range of 1000 $\mu g/m^3$ can generally be achieved; with two-stage filtration (and air washing), levels not exceeding 500 $\mu g/m^3$ may be expected; if efficient third stage filtration is added (assuming appropriate collection devices and air volume), workroom dust concentrations will generally not exceed 200 $\mu g/m^3$ for an eight hour time-weighted-average (TWA). Dr. Affify of North Carolina State University expressed the belief that dust levels of 200 $\mu g/m^3$ could be achieved in the textile industry simply by use of primary and secondary filtration systems without requiring the tertiary system recommended by Pneumafil and RTI.

In view of the foregoing evidence, OSHA concludes that application of LEV should achieve significant reductions in cotton dust concentrations. Use of LEV has been demonstrated to be successful in past applications and should continue to constitute an effective dust control strategy when applied to new processes.

(b) *Modification or isolation of a process.* Isolation consists of providing enclosures for equipment or complete separation of one work area from another (Ex. 93f). Commenters recommended more complete enclosure or containment of processing equipment and transfer conveyors to minimize dispersal of dust into the air as a result of air movement within the workroom (Ex. 17, p. 6). Further, total isolation of dusty operations such as card rooms and even isolation or separation of filtration systems is recognized as a practical approach to achieving compliance with permissible exposure limits herein prescribed and, indeed, this approach has been adopted in industrial settings (Ex. 1, #127).

Modification of production equipment consists of designing automatic opening systems and automated feedsystems, the utilization of high-speed cards (Ex. 78, Ex. 16), or the addition of oil to the cotton before processing (Tr. 542). In fact, current industrial practices are employing this prrinciple more and more as evidenced by examples given in the RTI report (Ex. 16, A-9). Some operations have already been converted from manual to mechanical handling of cotton. For instance, in the opening/cleaning operations, automatic Karousel-type openers are used and transfer is automatically accomplished (Ex. 16, A-9). Cottonseed processors estimate that a single cottonseed mill handles approximately 8,000 lbs. of dust per day by pneumatic and mechanical conveying equipment (Ex. 93f, p. 6). In all these cases where automation has been utilized reduced dust levels have resulted.

OSHA notes that in many instances, isolation and modification of production equipment have been used in combination in an attempt to reduce dust exposures in the workplace. The use of two control techniques is not only reasonable but, in fact, total compliance often involves utilization of multiple control strategies.

(c) *Work practices.* Generally, it is accepted as "good industrial hygiene practice" to provide adequate maintenance for control and ventilation equipment. Testimony presented during the hearings indicated that significant reductions of cotton dust levels in the cotton industry could be achieved by simply maximizing the effectiveness of the existing control devices (Ex. 17, p. 4). Maintenance of local exhaust hoods, ductwork, dust collection equipment, and fans in optimum condition; programs of total system maintenance and good work practices must be utilized, or the most highly sophisticated engineering control systems will not be effective in reducing dust levels (Ex. 17, p. 6). OSHA realizes that even after exposures have been reduced below the permissible exposure limits, good work practices must be continued if such limits are to be maintained.

(d) Substitution is the practice of using a substance of less toxicity in place of one of greater toxicity. In the case of cotton dust control, this refers to using synthetic fibers as a substitute for cotton. There are constraints which may make utilization of substitution as a control measure infeasible, such as product design and consumer acceptability (Ex. 16, p. 27). Where blends of synthetic and cotton fibers have been used, lower byssinosis-producing dust levels have resulted (Ex. 1, Merchant).

In the foregoing discussion, OSHA has reviewed the general control principles entered into the record in support of the technological feasibility of the cotton dust standard. OSHA believes that application of these principles will bring the cotton industry into compliance with the environmental levels required by the standard. The general discussion also included examples of the successful implementation of these general principles to reduce concentrations of cotton dust.

In the following sections, examples of specific control technology are presented from the record for each distinct operation in the industry. It is clear from the evidence that the evolution of specific technology has resulted in major reductions in cotton dust levels in a wide range of processes. OSHA believes that employment of the technology listed in the following sections and continued experience in applying general principles to specific problems will bring most of the industry within reach of compliance with the standard.

TEXTILES (EXCEPT WEAVING)

The general principles of ventilation control have been utilized to a greater extent and over a longer period of time in the textile industry than in any other sector of the cotton industry.

OSHA recognizes that with the general knowledge possessed by the industry, in most cases only refinement is necessary to adapt dust control systems to the capture of respirable particulates instead of lint and large waste materials.

Cotton lint arrives at the textile mill in hydraulically compressed packaged bales. At the mill the bale covering is removed and the contents are passed through the opening machinery which exposes it to successive processes of intense decompression, beating, cleaning, and mixing. During these operations, dirt and other heavy impurities are removed by gravity or by centrifugal force through grids or screens. Cotton from the opening equipment is usually conveyed pneumatically to the picker room where it is fed evenly to the pickers which further open and clean the cotton and deliver either a picker lap, a flat thick batt of randomly oriented fibers, or pneumatically conveyed loose cotton lint to the carding machinery. Carding machines comb the fiber so that it lies straight and parallel and some cleaning is also effected. Large quantities of dust can be produced by this process and the card room has traditionally been one of the dustiest workrooms in a mill. The main processes in a spinning mill after carding are: drawing to obtain thorough fiber mixing and weight uniformity, roving to draw the sliver down to one fourth to one-eighth its original size and slightly twist it, and spinning to give considerable fine draft to the soft roving and twist it into yarn. Processes subsequent to spinning are only amalgamation of yarn units or changes in the form of the package and result in the production of a yarn in a form suitable for dispatch to the fabric manufacturing mill.

With this overview, the testimony compiled on existing technology pertaining to each operation becomes more relevant. Clearly, it appears that the effect each operation has on preceding or following operations greatly influences the total dust levels in the general workplace.

OPENING AND CLEANING

The purpose of this process is to open, separate, and remove trash from the cotton fiber. Common sources of cotton dust exposure are manual feeding of blending feeders, the blending hoppers, exposed feed tables or conveyors, pressure points in openers, and the condenser (Ex. 16, A-6: Ex. 1 #127, p. 11). Although the machines are usually fairly well enclosed and are equipped with a type of exhaust system effective in removing larger diameter particles, respirable dust levels are still high (Ex. 16, A-6). ACTWU illustrated, in some recent surveys which they compiled, that, the modernized plants e.g., Flint Plant, have automated opening and switched to chute-fed cards with effective built in ventilation, and now have reduced dust levels significantly to ranges of 100 and 210 $\mu g/m^3$, with only 2 of the operating areas recording more than 200 $\mu g/m^3$ levels. Union representatives also discussed additional systems instrumental in significantly reducing dust levels in this process, such as systems to eliminate feeding of stock into hoppers by hand, automatic bale plucking systems and improved cleaning equipment (ACTWU, p. 21).

In the feasibility study done for NIOSH by Pneumafil, evidence was presented indicating the feasibility of achieving a permissible esposure limit of 200 $\mu g/m^3$ in operations from opening through roving. In fact, in one plant surveyed in 1972 by Hocutt, suction hoods had been installed with direct connections to specific machines, condensers had been installed in transport lines from blenders to cleaning equipment, condensers had been installed in transport lines from cleaning equipment to cards (Ex. 1, #127, p. 20) and hoods were installed over feed tables and blending hopper lines. The efficiency of the system was tested and vertical elutriator samples found a median dust level of 360 $\mu g/m^3$. However, as Hocutt pointed out, the primary purpose of this system was to control lint and visible dust (Ex. 1, #127, p. 21). Upgrading the ventilation system is expected to bring levels into compliance with the required 200 $\mu g/m^3$ permissible exposure limit (Ex. 17, Ex. 37, Ex. 60, Ex. 85).

Picking. The main purpose of picking is to continue with opening the fiber, and removing trash and short fibers, for the purpose of mixing the process cotton and forming a uniform lap (Ex. 16, A-9). Dust generation results from internal mechanical action, inadequate filtration devices located on the pressure side of the condensor fan, manual doffing and handling of the picker lap (Ex. 16, A-9).

Hocutt, in a survey, examined the dust handling capacity of a picking operation where the entire lint and dust capture system was ducted to a single filtration system. The results of this 1973 installation were dust levels which dropped from a median of 1006 to 300 $\mu g/m^3$. Once again, this system was designed to control visible lint and dust only (Ex. 1, #127, p. 23), so that further reductions can be anticipated when the system is adapted for removal of respirable particulates.

Union personnel suggest that very few improvements will be made on pickers and in fact existing pickers will only be maintained until they can be replaced with automatic opening and chute-fed cards. This replacement would eliminate the picking operation (ACTWU, Appendix G).

Carding. Studies indicate that the cotton card may be the greatest source of dust production in the cotton textile mill. Several commenters recommeded certain control techniques for reducing the emissions in this area of operation. For example, most of the undercard waste can be collected by the dust control system simply by adding a plenum to the system. In addition, on high speed plates, undercard suction is necessary to prevent excessive blow out of fine dust.

Union personnel pointed out that replacement of conventional cards with high speed cards tends to reduce dust levels (Appendix K, ACTWU). Further, the chute-fed system for carding keeps dust and lint confined within the chutes, therefore maintaining a much cleaner environment (ACTWU, Appendix G). Of the 20,000 high speed cards operating, 5,000 or 25% are chute-fed. (ACTWU, p. 21). Chute-fed

high-speed cards have reduced dust levels from 300 $\mu g/m^3$ to 70 $\mu g/m^3$ in card rooms (this represents a 200-500 $\mu g/m^3$ TWA) processing low grade cotton (low grade cotton generates more trash) (p. 32 ACTWU). Neefus noted reductions from 440 to 190 $\mu g/m^3$ and Imbus measured levels of 2000-725 (range of 200-500 $\mu g/m^3$ TWA) after installation of chute-fed cards in the carding area (Ex. 37, 7). It should, however, be emphasized that chute feeding was not designed to reduce dust levels but instead to increase productivity.

Alternatives other than card replacement have been used successfully to reduce dust levels. Hocutt reported on one alternative approach. The plant had installed a lint and dust capture system consisting of suction tubing at both ends of the plenum for maximum air quality, an undercard suction plenum which collected the trash and fly falling out beneath the lickering device (Ex. 1, #127, p. 36) and finally a suction nozzle at the trumpet on the coiler completed the capture system.

Vertical elutriated dust samples taken at three strategic locations were 750 $\mu g/m^3$, 300 $\mu g/m^3$, and 430 $\mu g/m^3$. The undercard system had contributed 82% to the air quality per card and 100% to the dust control system, totally.

Hocutt maintained that dust levels could be reduced even to lesser levels by the addition of more filtration consisting of adding a two-stage rotary drum filter between the secondary preseparator and the air-conditioning system.

It was generally agreed that a 200 $\mu g/m^3$ level could be obtained with installation of ventilation equipment designed to efficiently collect respirable particulates (Ex. 60, Ex. 37, Ex. 69, Ex. 17, Ex. 114).

Drawing. Slivers from the cards pass through drawing frames where several slivers are pulled together between rollers. The purpose is to straighten the fibers and reduce the size of the strand which they compose. Draw frames are enclosed and controlled by a type of dust control system. Draw frames are not believed to contribute seriously to dust loads in the room. Further, the desired level of control may be affected relatively easily by capturing and filtering the output from the internal dust control system.

Hocutt testified during the hearings (Ex. 60, p. 7) that the technology to reduce respirable dust levels is relevant and when applied should achieve a 200 $\mu g/m^3$ permissible exposures limit. His conclusion was based on a long-time familiarity with these machines. Further, NIOSH reports a 180 $\mu g/m^3$ dust level for a drawing operation in one plant which lacked any control equipment other than that provided by general room ventilation (Ex. 37, 7).

Combing. The primary purpose of this operation is to remove short fibers, neps, and waste particles in order to make the fibers parallel, make the fiber strands uniform, and blend the fibers. Most dust and fly generated come from the aspirator fan which discharges directly into the room environment at each comber. A small quantity of dust can be expected to be generated at the coiler and the draw box. Since combing is done only on long staple, high grade cottons which are relatively dust free, combing is unlikely to be a significant source of air contamination (Ex. 16).

While it appears that combing operations, for the most part, will not require significant ventilation improvements, Hocutt expressed his view that in some cases installation of ventilation equipment may be necessary to reduce exposure limits to 200 $\mu g/m^3$. OSHA realizes that some plants may experience difficulty in installing ventilation equipment, however, as more experience is gained in controlling these difficult areas, implementation will become easier.

Roving. The sliver from the draw frame may also proceed to the roving frame which reduces the size of the sliver by roller drawing, imparts a slight twist, and winds the product on bobbins for spinning. Exposure measurements taken in these areas indicate that levels are low, and in fact generally are below the permissible exposure limits. In fact, vendors of ventilation systems did not suggest that any control was necessary when queried (Ex. 16).

Hocutt did suggest that in some instances roving may need additional controls to achieve the 200 $\mu g/m^3$ permissible exposure level. For example, in roving areas of some mills producing medium to fine counts, the discharge from the collector unit on each roving frame and conventional filters might have to be collected (Ex. 60, p. 9); whereas in coarse count mills using relatively low grade stock, a rectangular plenum must be mounted inside or behind the Samson with suction slots on the flyer side.

OSHA realizes that isolated cases such as those discussed by Hocutt will be a recurring problem and that some added efforts may always be necessary to achieve compliance with the prescribed standard in some operations.

ACTWU (p. 21) emphasized that with the advent of the open-end spinning system, a question mark can be placed on the future of the roving frame. In fact, ACTWU expects no substantial developments in dust control technology in this area. However, OSHA requires that where developments in the technology are necessary they be made. The anticipation that new technology will ultimately replace existing technology can not be used as a substitute for applying available control remedies to existing operations.

Spinning. There are basically two types of spinning processes, traditional ring and open-end, with traditional ring spinning frames comprising 95% of total spinning production equipment (Ex. 16). The combination of reduction in yarn diameter and high air speeds across the yarn create the opportunity for release of a portion of fine trash remaining at the spinning operations.

To eliminate waste, all spinning frames are equipped with "loose ends" collection systems for cotton yarn that breaks in processing. This collection system alone is sufficient to prevent airborne dust concentrations from exceeding 1000 $\mu g/m^3$. In order to reduce levels even lower, the exhaust from the ends collection system which is normally recirculated back into the room, must be captured by an external dust collection device (RTI, Ex. 16).

Hocutt maintained that it would not be feasible to reduce dust levels in all spinning operations to levels lower than 500 $\mu g/m^3$. His position was based on the difficulty in working with some equipment, and the configuration or the lack of space needed to install ventilation equipment. OSHA is aware that confounding factors exist in some mills which make installation of ventilation equipment difficult. However, when more attention has been given to general principles of ventilation control, this has in many instances sufficed to reduce levels to within those herein prescribed. Further, when the entire process is viewed rather than each operation independently, it becomes clear that reduction in dust levels in beginning operations may affect the levels in final operations. Further, in some instances isolation of spinning from dustier operations could be utilized along with additional general ventilation improvements to bring levels to within those herein prescribed. In the past, application of principles described above have been used successfully to reduce dust levels in the workplace, and it is reasonable to anticipate that this is what will be done now.

Open-end Spinning/Traditional Ring Spinning. Open-end spinning differs from traditional ring spinning in that it is enclosed and under negative pressure. Neefus reports a reduction in dust levels from 780 to 170 $\mu g/m^3$ in one plant (Ex. 37, 7) which converted to open end spinning. Industry reports level reductions ranging from 690 to 210 $\mu g/m^3$ when open end spinning replaced ring-spinning. Further, if operations would switch from ring spinning to open end spinning the cost is reduced (Tr. 2593). However, open end spinning (Tr. 2724) still requires local exhaust ventilation over frame filters to achieve compliance with 200 $\mu g/m^3$

permissible exposure limit. Basically, open end spinning is more adaptable to the installation of local exhaust ventilation than is traditional ring spinning and because of this provides reduced dust levels in the work environment.

ACTWU (p. 19) discussed the advent of the open or rotor spinning frames and the impact it is having on ring spinning. These new frames eliminate the need for roving and winding. Spinning is performed in enclosed rotors with build-in suction to minimize dust emission. However, this process has not been found suitable for all types of cotton yarns at present. Based on past experience open end spinning may not be adaptable for use with yarn counts beyond twenty (not for fine counts just for coarser counts). However, where adaptable, open end spinning has several important advantages over ring spinning, in addition to the reduction of cotton dust. One advantage of using open end spinning is that cotton of a far lower grade can be processed than with ring spinning. In addition, the open end spinning frame in combination with the chute fed card would replace eight conventional processes with two, so there appears to be an economic advantage in continued perfection of the open end spinning frame. Union witnesses also pointed out that there are 168,792 spindles of open end spinning in place currently. Further, ACTWU also projected that a long staple open end spinning frame will be developed with major influence in replacing the ring spinning frame.

OSHA realizes the uncertainty involved in awaiting the development of a long staple open end spinning frame, and it is for this reason that OSHA concludes that control strategies must be implemented which rely upon what can be done with existing equipment. OSHA encourages technology innovation as a future strategy for eliminating dust. However, for the present general principles of ventilation control coupled with proven and applied control strategies must be relied upon and will, in OSHA's judgment, be sucessful in bringing dust levels to within those herein prescribed.

OSHA considered the arguments presented by both industry and union representatives in ascertaining which permissible exposure limits are feasible for the spinning operation. It is OSHA's belief that spinning will require some effort to comply with the 200 $\mu g/m^3$ level set for the textile industry. When each operation in the textile process is examined with regard to its relationship to subsequent operations, it is clear that reducing dust levels in operations from opening to roving would aid in the reduction of dust levels in areas of final processing such as spinning. Further, general practicies such as ventilation installation, process isolation, and equipment modification are recommended as strategies for controlling dust levels to the limits required. These strategies have proven successful in many instances. However, little work has been done as yet to adapt these principles to dust control in spinning, particularly with a goal of reducing respirable particulates. Without underestimating the difficulties in achieving the limit required, OSHA believes that a major effort to solve the dust control problem in spinning using the strategies enumerated and relying on experience gained in other textile operations will produce successful results. OSHA notes that, with the application of a higher permissible exposure level in weaving, the industry can focus more resources on spinning operations.

Therefore, OSHA concludes, based on knowledge of sound environmental control provisions, that with the utilization of these techniques in addition to specific controls which have been implemented in the past, permissible exposure limits can be reduced to within those limits herein prescribed.

Winding, Spooling, Twisting, and Warping. These are processes by which yarn is either transferred from one package to another, defects are removed, twisted or wound into a ball for later processing. Levels in all these operations are currently very low and are not expected to present a compliance problem (Ex. 16, A-40; Ex. 38, NIOSH, Ex. 16). OSHA realizes that inherent operational difficulties found in some operations may require increased effort to reduce dust levels to 200 $\mu g/m^3$; however, OSHA agrees with RTI's assessments and concludes that the vast majority of workplaces will be able to comply with little difficulty.

Weaving and Slashing. Weaving is the process of interlacing two sets of yarn, one running lengthwise on a loom, the other crosswise, by means of a shuttle. This results in a woven fabric, ready for finishing processes such as dyeing.

The permissible exposure limit for weaving and slashing was set at 750 $\mu g/m^3$. OSHA's decision was based solely on epidemiological evidence indicating a lower prevalence of byssinosis among workers involved in this operation than in yarn preparation. Evidence clearly demonstrated that the airborne materials released during this process are not totally cotton dust but consist, in part, of starch materials. OSHA concludes, based on the evidence in the record, that the 750 $\mu g/m^3$ level for weaving and slashing is both economically and technologically feasible. In fact, industry's expert witness estimates that existing levels in 72% of the weaving operations are already in compliance with a 750 $\mu g/m^3$ permissible exposure limit (Tr. 2419).

Some industry spokespersons indicated that weaving operations peculiar to their own mills may not be able to comply with a 750 $\mu g/m^3$. They maintain that controlling exposures in some weave rooms to less than 1000 $\mu g/m^3$ would be difficult (Tr. 2532). OSHA is aware that particular plants or equipment configurations may make compliance in some weaving operations more difficult. However, based on the experience acquired, it is believed that the application of general principles of ventilation control can be used to reduce exposure limits in these situations. In fact, this is what has been done in the past (Tr. 2552, Ex. 37, 7, Tr. 2419).

Numerous hearing participants presented evidence on specific methods which have been used to achieve reduced dust levels in weaving operations. One method recommended increasing the air flow under the looms which normally are exhausting air away for purposes of moisture control (Tr. 2725). Where air flow has been increased to 20,000 cfm per loom, readings of dust levels in the work place were 750 $\mu g/m^3$ (Tr. 2552). Finally, exposure readings taken by NIOSH representatives recorded exposure limits as low as 370 $\mu g/m^3$ in weave rooms where only room ventilation was being used (Ex. 37, 7).

RTI suggested three basic approaches to compliance. First, isolating weave rooms from dusty processes; secondly, using separate room ventalation equipment, so that dust is not introduced through recirculation, and thirdly, installing local exhaust ventilation.

Evidence was presented which clearly demonstrates the feasibility of compliance with a 750 $\mu g/m^3$ level in slashing/weaving operations. Several commenters presented evidence on exposure measurements taken at various weaving operations demonstrating current exposure levels considerably less than the 750 $\mu g/m^3$ permissible exposure limit (Tr. 2552: Tr. 2583; Ex. 37-7). Further, reduction of dust levels in other areas of the textile plant will often aid compliance in areas where specific engineering controls may not be as readily applicable.

Non-textiles. As discussed in detail above, the permissible exposure limit for non-textile operations is 500 $\mu g/m^3$. Based on a thorough evaluation of the record, this level is considered both technologically and economically feasible for the non-textile operations. It should be emphasized that the non-textile sector does not have a history of using dust control equipment comparable to the textile industry. In many instances, even general ventilation equipment has not been used, and in fact primary reliance has been

placed on respirators for reducing employee exposure to cotton dust. In addition to the lack of experience with dust control techniques, compliance in the non-textile industries is complicated by a lack of uniformity in operations. However, where some application of the general methods of engineering control have been employed, achievement of a 500 $\mu g/m^3$ permissible exposure limit has become feasible. OSHA is of the view on the basis of the evidence and examples discussed more fully below, that further application of these general engineering control principles to the various non-textile operations will successfully reduce exposure to the 500 $\mu g/m^3$ permissable limit. The application of these principles is discussed below.

Warehousing. Exposure data collected in five warehouses indicate that many warehousing operations are already in compliance with a 500 $\mu g/m^3$ permissible exposure limit. Specifically, exposure measurements taken in the receiving and sampling areas ranged from 140–410 $\mu g/m^3$ (97 f, p. 14). Industry representatives estimate that depending upon the geographic conditions, dust levels in these areas will generally be 200 $\mu g/m^3$. Storage area samples taken were approximately 235 $\mu g/m^3$ and industry spokesperson estimate that compliance would be facilitated simply by house cleaning. Further, levels as low as 30 and 40 $\mu g/m^3$ were found in dead storage. In the dinky press area levels ranging from 160–410 $\mu g/m^3$ were recorded; warehousing representatives estimate that exposure levels in this area will not exceed 500 $\mu g/m^3$. Finally, in the loose room average levels of 300–580 $\mu g/m^3$ were measured. Industry spokespersons commented that this area represented the highest exposure patterns and that compliance would require some installation of ventilation improvements. Warehousing spokespersons estimate that housekeeping alone would maintain dust levels to within the 200 $\mu g/m^3$ standard contained in the proposal (97 f).

The compress is a major exposure point in those warehouses which compress cotton bales. (Ex. 95) Approximately half of all warehouses perform compressing, which represents mostly those facilities with the greatest storage capacity (Ex. 95 b,c). While the limited testimony on compressing indicates that engineering controls for the massive compress would be difficult because of the rapid displacement of air caused by the compression of the bale no data representative of dust levels at the compress in excess of 500 $\mu g/m^3$ were offered by industry. Furthermore, engineering testimony presented by warehousing representatives generally supported feasibilty of the 500 $\mu g/m^3$ limit.

Classing Offices. Classing offices have reported dust levels as high as 2400 $\mu g/m^3$ in some southern regional offices. These levels were found in offices where no ventilation controls had been provided. As a result of this information on exposure limits, some classing offices began to install minor ventilation systems. Systems of fans and filters designed to capture dust at the table top level, filter the dust out of the air, and exhaust the cleaned air back to the workplace were installed (air was not exhausted to the outside because temperature and humidity control are required in classing offices.) The result of these first attempts at improvements was a reduction in exposure limits to levels as low as 120 $\mu g/m^3$. Further, investigators noted that reduction in dust level depends a great deal upon the rate of air exchange in the work area. In one particular office, variations of 1.5–11.0 minute differences in air flow rates were responsible for higher dust levels.

Based on the information presented during the hearing regarding exposure in classing offices, OSHA concludes that compliance will be readily achievable with the installation of ventilation equipment. Indeed, it appears that only minor changes should be necessary to produce required levels.

Knitting. Initially, the discussion of technological feasibility for knitting manufacturers' was omitted from the RTI study. This was due in part to the lack of data pertaining to existing dust levels resulting from this operation (Ex. 16). However, during the hearings, Mr. R. L. Thistlewaite of the National Knitwear Industry presented testimony on dust levels which were common to this operation. In a three month study which he conducted in a knitwear plant, he measured dust levels of 40–90 $\mu g/m^3$ (Ex. 149). These levels substantiated his hearing testimony in which he stated that the industry, in general, was in compliance with the then proposed 200 $\mu g/m^3$ permissible exposure limit (TR 4218).

Since the final regulation provides for a higher permissible exposure limit (500 $\mu g/cu\ m$), OSHA concludes that compliance in this portion of the industry is clearly feasible.

Waste Processing. In preparation for the hearings, cotton waste processors jointly developed an economic and technological analysis of their industry. The results indicated (Booker, p. 2, Cotton Waste Recyclers) that a permissible exposure limit of 500 $\mu g/m^3$ could be achieved by using specially designed dust capture devices at emission points, exhaust fans for drawing dust laden air out of the work place, and high efficiency filtering systems for removing dusts. There is no suggestion that these controls cannot be adapted and applied to achieve the 500 $\mu g/m^3$ exposure limit. A discussion of some of the processes included in waste processing and the application of control techniques considered suitable for these processes is presented below.

Garnetting. NIOSH conducted a survey of garnetting operations to ascertain what dust exposures were present in these operations. Dust control equipment consisted of a series of round ducts extending vertically down from large ducts on each side of the machine. Average air flow rate of 4600 cfm was supplied through this ducting system. The filtration system consisted of a pre-separator, a rotating drum, a secondary filter and a tertiary vee cell filter. Air was discharged into a different room and recycled through an air conditioning system. Vertical elutriator dust measurements showed dust levels of 650 $\mu g/m^3$.

NIOSH recommended redesign of the dust capture equipment as a method of improving control in this operation. Side ducts are inefficient in directing captured air and hooding should be used over emission points instead. Filter efficiency should be checked since return air recycled back into the work place contained levels of 190 $\mu g/m^3$. Improvement in the controls, along the line suggested by NIOSH or others should readily reduce exposures below 500 $\mu g/m^3$.

Since the garnetting operation is similar to some textile operations, control techniques recommended for textile operations such as hooding over the picker feeder hopper, capture of the air from the picker beater fans, specially designed removable covers placed over garnetts, and hoods installed over lappers are expected to reduce dust levels in garnetting operations. (Ex. 16, IV-17). Further, increased air flows and improved filtration should reduce levels (Ex. 16, IV-17). Vendors of dust control equipment presented evidence at the cotton dust hearings which supported the feasibility of the suggestions made by RTI for reducing exposures, and agreed that exposures can be reduced to levels of 500 $\mu g/m^3$.

Nonwoven Fabric and Surgical Dressings. Limited evidence was presented during the hearings regarding exposures in this process. RTI estimated that exposures could be controlled by implementing controls recommended for the yarn production industry. Cards and pickers used in processing of woven fabric and surgical dressings are very similar in physical configuration and emission rates, so that it can be anticipated that local exhaust ventilation used in yarn production can be adapted here also. (Ex. 16, IV-18).

Mattresses and Bedsprings. Major exposure to cotton dust arises in the manual handling of the cotton batting and through operation of the quilting machines. One solution suggested is to eliminate, whenever possible, manual

handling of cotton in order to assure that employee exposures are maintained at or below 500 $\mu g/m^3$. While RTI suggested hooding of the quilting machines as a method for reducing employee exposure, they indicated that work practices alone may provide the most satisfactory means of achieving and maintaining a 500 $\mu g/m^3$ standard. Vendors generally agreed with RTI's assessment and believed that compliance with a 500 $\mu g/m^3$ standard is obtainable by utilizing control techniques similar to those generally recommended for controlling waste processing. The National Association of Bedding Manufacturers (NABM) conferred with vendors (p. 50) and feels that compliance with a 500 $\mu g/m^3$ limit is possible if capture hoods, ducts, filters and waste handling equipment are utilized. Limited data collected by NIOSH indicates that some operations are already well below the permissible exposure level. With the proper application of available dust control technology, no difficulty is expected in reaching the permissible exposure limit.

Spun Yarn. Much of the equipment utilized in the manufacture of yarn from cotton waste is similar to the equipment used in the manufacture of yarn from raw cotton. It is expected that ventilation equipment suggested for controlling dust exposures in the manufacture of yarn from raw cotton would be adaptable to operations which make yarn from cotton waste. Further, vendors of ventilation equipment (National Cotton Council of America, EIS) estimated that compliance with a 500 $\mu g/m^3$ standard was achievable in this operation.

Cottonseed Oil Production. The cottonseed oil production process consists of taking cottonseed which has been stored in the open air or in large warehouses, transporting it to the mill by screw conveyors which are fed by hand, and then passing it through one or more cleaning (delinting) stages. At the delinting stage, fuzz is removed by one or two passes through the machinery. Linters are baled and sold for use in the waste processing and seeds are transferred to areas for crushing and oil extraction. Potential sources of exposure are the seed storage house, and the cleaning, delinting, and baling operations.

Data on dust levels in cotton seed mills is scanty. It appears that levels, where reported, are high in relation to the prescribed level. However, dust measurements reported by Dr. Hans Weill were as low as 300 $\mu g/m^3$ at major exposure points in one mill. According to Dr. Weill, the reduced levels at this plant were probably explained by the cleaner variety of seed processed, by the installation of 1972 of newly designed machines, and by the effects of improvements resulting from vigorous local enforcement of air pollution control (Ex. 125). While these explanations were presented merely as speculation, they generally coincide with the methods offered by hearing participants as those general approaches most likely to result in reductions in dust levels.

The cotton seed receiving area generally has high dust levels which result from the dumping of cotton seed and the vacuum unloader. Industry reports indicate that dusts levels in this area can successfully be controlled by partially or completely enclosing the seed dump and exhausting dust laden air from the dump area (Ex. 128L).

Cleaning rooms have very high dust levels and would require extensive removal of dust to come into compliance. Newer equipment such as enclosed sand and boll reel cleaners or air classification equipment should reduce dust levels. One mill passes seed first through a zig-zag separator before passing through an air classifier. This has proven very successful in cleaning the seed while at the same time reducing dust levels (Ex. 128L).

The feasibility study completed by the National Cottonseed Producers Assoc. recommended that dust generating areas of the cleaner be enclosed to insure dust entrapment by placing hoods directly on the top of the cleaner rack. A box would also be constructed to catch bolls and trash at the rear of the cleaner. In general, the study recommends isolating the cleaning room from other processes, and using a baghouse to prefilter all incoming process and exhaust air (primarily due to the heavy loading of particulates in the outside air). Further, a make-up air system would have to be installed to supply prefiltered air for replenishing process stream air and hood air. Several techniques, in addition to ventilation control, have proven effective in reducing exposure limits in the linter rooms. Basically, there are three methods presently used for delinting: saw delinting, abrasive delinting, and acid delinting with sulfuric acid. All three methods have significantly resulted in reduced dust levels in the delinting area, although abrasive and acid delinting may create elevated dust levels in the hulling areas (128 J).

Abrasive delinters, however, can be completely sealed to prevent leakage. Further, an advantage exists with an abrasive delinter in that it is possible to use fabric filters to control emissions from the delinting operations. This requires that the total air handled is less with the abrasive linters therefore, less air need be cleaned, thereby significantly reducing the amount of air returned to the workplace environment.

Acid gas delinters not only provide improved dust control but also decrease labor and energy requirements, and decrease equipment and maintenance costs.

Parnell recommended a system of hooding in saw delinters in order to achieve low dust levels in linter rooms. Parnell referred to work done by Leonard in designing the linter hood systems. Addition of this hooding system should reduce levels to the permissible exposure limit of 500 $\mu g/m^3$ set in the final standard (pp. 30-39). Other industry representatives suggested the use of high efficiency cyclones in separation systems along with secondary air filtration equipment as a method of achieving compliance.

OSHA realizes that achieving 500 $\mu g/m^3$ in most cotton seed oil mills will require considerable effort on the part of the industry. However, this effort will involve only an application of existing controls and is not likely to necessitate technological innovation. There appears to be no reason for concluding that a reasonable effort at implementing general dust control principles such as those suggested above, along with the adoption of "common sense" work practices will not bring the majority of cotton seed oil mills into compliance with the permissible exposure limit.

V. Economic Considerations

To assess the economic feasibility of the proposed standard for cotton dust, OSHA undertook a study of the proposal's economic impact on the affected industry. This study was conducted for OSHA by the Research Triangle Institute (RTI) (IIS). Additional information was obtained through OSHA's analysis and consideration of all other economic data, comments, arguments and testimony submitted at the hearings, in pre-hearing comments and in post-hearing comments and briefs. On the basis of the best available evidence, therefore, OSHA has determined, as explained in detail below, that the permanent cotton dust standard is economically feasible.

COMPLIANCE COSTS

Estimates of the total costs of compliance with the permanent cotton dust standard for the major affected industries are as follows: Capital costs of $656.5 million, and annualized costs of $206.1 million. The textile and non-textile estimates of costs of compliance are separately analyzed below. As that analysis indicates, estimated costs are within the financial capability of the affected industries. Thus OSHA has concluded that the cotton dust standard is economically feasible and that the regulated industries are able to bear the costs of compliance with this standard.

OSHA's estimates of total costs for compliance with the final standard are

significantly lower than estimates of the proposal's compliance costs, in part because the standard in its final form differs from the proposal in areas which significantly impact on the cost of compliance. A primary difference is that the proposal would have required all textile and non-textile employers to reduce employee exposure to cotton dust to 200 $\mu g/m^3$, whereas the final standard requires the reduction of employee exposure to 200 $\mu g/m^3$ only in yarn manufacturing processes from opening up to, but not including, slashing and weaving. Thus, estimates of capital costs for engineering controls have been reduced for those processes or industries for which higher permissible exposure limits have been set in the final standard. In addition, total compliance costs for the proposed cotton dust standard included costs of compliance for cotton gins which are excluded from the scope of this final standard and are covered by a separate regulation (29 CFR 1910.1046). Estimates of costs of compliance for the principal industry sectors and the major cost-related provisions of the regulation are summarized below. In most cases, OSHA has reviewed and accepted the bases of the cost estimates presented in industry testimony, though these have sometimes been adjusted.

Costs were separately estimated for the required compliance activities of monitoring, engineering controls, work practices, medical surveillance, respirators, training, signs and recordkeeping. Costs for each of these activities, other than engineering controls, have primarily been based on RTI's cost estimates. The primary focus of the participants to the cotton dust rulemaking was on costs for engineering controls and work practices, and in the absence of substantially contradictory testimony and alternative methods from affected industries, the approach of RTI has been largely adopted by OSHA in estimating the cost of compliance with the monitoring, medical surveillance, respirator, training, signs and recordkeeping requirements of the final standard.

TEXTILE INDUSTRY

The cotton textile industry was described in detail by RTI (IIS, Appendix A). As noted, data for the sectors examined indicate only moderate industrial concentration, with about 25 percent of the largest firms in weaving sectors accounting for about 70 percent of sales and with seven percent of the yarn firms accounting for 30 percent of sales.

The profits in textiles have historically been cyclical and low, compared to those in other manufacturing industries, in terms of the dollar values in relation to sales or as returns on investment. However, between 1969 to 1974 the textile industry's rate of return on investment improved relative to other manufacturing industries, and has been about four percent since 1971. Competition from synthetic fibers reduced the cotton share of the total domestic fiber market to less than 30 percent in 1974. Studies of interfiber competition have not yet fully taken into account changes in oil prices in recent years. Such changes, along with others in foreign trade levels, may have important effects on the textile industry. However, RTI estimated the inflationary impact of the regulation on the basis that costs of compliance will be passed on in output prices and that general industry profit rates would be maintained.

A. *Cost of Engineering Controls.* The principal component of the estimated costs of compliance will be in cotton textile industry, and the level of total annualized costs will be largely determined by the requirements for capital spending for engineering controls.

During the cotton dust rulemaking, differing cost estimates for engineering controls in textile operations were submitted by various participants. The differences in the cost estimates were the result of differences in assumptions as to current exposure levels, data available, methods for determining and annualizing capital costs and methods and periods for depreciation.

1. Capital Costs. Table 1 shows the various estimates of costs of engineering controls for the textile industry. Industry—wide costs were based on the application of controls to all production equipment in mills processing cotton and cotton blends, regardless of the fiber processed by particular equipment and even if part of the production were pure synthetics. Although cotton dust is not generated by equipment used to process synthetics (and, consequently mills processing only man-made fiber are exempt from the final standard), RTI included such equipment in its cost estimates because in a plant processing cotton blends, which would be covered by the standard, this equipment is substitutable for cotton processing machines. RTI said that exclusion of equipment used to process synthetics in cotton blend mills could reduce yarn production control costs by as much as 30 percent (IIS, pp. V-13, V-14).

RTI made an assumption of compliance with the previous cotton dust standard (29 CFR 1910.1000 Table Z-1) thus assessing only the incremental costs of moving into compliance with the proposal. While assumption of compliance with the previous regulation underestimates the actual costs in processes that are not in compliance with that regulation, RTI may have over-estimated compliance costs since some operations are already in compliance with the permissible exposure limit of the new standard. Dr. David LeSourd of RTI explained that RTI did not have data on the degree of compliance in the industry as a whole, but instead only had data for some specific mills (TR 617-622). Dr. LeSourd also said RTI did not take into account recent or projected changes in textile production technology (noted in a 1974 ATMI report) because he felt they would not affect the way the industry would achieve compliance or the costs of compliance with the proposed regulation. Milton Wright, also of RTI, said costs of controlling dust on new and old machines were generally found to be the same for each machine. There was some cost reduction with use of high speed cards, and costs for them were separately estimated. He said 80 percent of the industry already use high speed cards, and some cotton cannot be processsed with that equipment. He also foresaw some saving in the use of open end spinning instead of ring spinning, but the products differ (TR 623, 624). RTI estimates of engineering control costs include purchase of equipment and costs of site preparation, installation and design engineering (IIS, p. VI-17).

L. K. Fitzgerald said ATMI found the conclusion in the IIS completely objective viewed from the persepective of the data available to RTI, but the RTI estimate of the costs of achieving 200 $\mu g/m^3$ were understated because of the assumption that the industry is in compliance with the current regulation, whereas in actuality such costs would still have to be incurred by the industry. He developed new estimates of capital and annual costs based on adding to the RTI estimate the sum of $143.3 million for the capital costs of compliance for yarn production. The basic reason that RTI excluded such costs was that they were related to complying with the previous regulation rather than with the proposed regulation; the $143.3 million in 1974 dollars was estimated as the cost of "going from zero dust control of compliance with the existing 1.0 mg/m^3 standard" (IIS, p. V-8). Moreover, RTI said the "actual level of controls in the cotton industry could not be determined," from data available to RTI, though they were aware of the investment and of the success in dust control in certain plants and firms.

In addition, testimony (e.g., in statements by Harold Imbus and Hovan Hocutt) made clear that substantial amounts of such controls are, in fact, in operation. Therefore, adding this amount to the incremental costs estimated by RTI would result in a substantial overstatment of the control expenditures the industry could reasonably anticipate. Further, Dr. Parker C. Reist provided some test data showing that, for some new machines, cfm (cubic feet per minute) re-

quirements per pound of cotton per hour declines as the number of pounds per hour rises with the installation of new machines (PH 3, App. K). This means that the essential cost of control goes down the more productive the machine is because the cost of the control is the same whether the machine is old or new. Thus Fitzgerald's addition of the $143.3 million to the RTI costs estimates would overstate costs of compliance by failing to recognize the value of existing efforts of the industry to control dust by retrofit of existing machines and by ignoring alternative control methods.

Mr. Fitzgerald also testified on the efforts of Mr. Hocutt to estimate industry costs for engineering controls. Mr. Hocutt used data of a recent ATMI survey which were not available to RTI and estimated industry costs in terms of current equipment prices for the permissible exposure levels advocated by ATMI (i.e. 500 $\mu g/m^3$ for opening through warping, and 1.0 $\mu g/m^3$ for slashing and weaving) (Ex. 69). It is not possible to compare all of the cost data for these yarn production estimates as reported by Mr. Fitzgerald directly with those offered by RTI or other sources because of these differences in exposure levels, in data bases and assumptions, and in grouping of production processes.

2. Annualized Cost of Capital. RTI calculated annualized costs of capital on the basis of several assumptions: depreciation was assumed to occur over a period of 14 years, in accordance with an earlier limit for textile equipment tax write-off periods established by the Internal Revenue Service; and assumed market interest rate of 10 percent; administrative overhead, equipment taxes and insurance at 2.5 percent a year, and, in the absence of a basis for estimation, zero salvage value for control equipment (IIS, pgs. VI-25, VI-16).

Industry agreed with this approach. However, Mr. Fitzgerald proposed changing the estimates of annualized costs calculated by RTI to reflect the reduction by the I.R.S. in the depreciation period from 14 to 9 years thus raising annualized costs of capital by about 23.5 percent. This might be appropriate if, in fact, the life of engineering controls were 9 years. However, no testimony was presented on the operating life period of such controls, nor was there recognition of the lower amounts of total interest charges that would occur if the controls were to be amortized over fewer years. Mr. Fitzgerald testified that decreasing the depreciation life increased the "paper cost" of the industries since length of borrowing time is keyed to depreciation period but permitted increased funds for internal financing because of accelerated recapture of capital making it easier for firms to buy equipment (Tr. 2735-2737).

He cited these among other factors to indicate that the textile industry would find it difficult to compete with other basic industries for external capital funds to finance the costs estimated by RTI (Tr. 2555-2556). RTI had also noted the financing problems associated with the costs of compliance in its analysis of industry market structure and profitability, especially for smaller firms (IIS, pp. VI-127-128). These effects are discussed below. However, in using a 10 percent interest rate in their calculations, RTI appears to have recognized some of the problems in external financing. It should be noted that lower rates have been used by other industries to annualize capital costs of compliance with other occupational health regulations. (Coke Ovens Emissions) Moreover, neither RTI nor ATMI used the investment tax credit in their calculations of capital costs. This would have reduced estimates of annualized costs.

The annualized capital charges estimated by RTI were calculated on a conservatively high basis. In the absence of evidence that the life of controls is substantially different from that of textile machinery, there is an argument for reducing the depreciation period for controls to that allowed for other equipment. However, the calculation of attendant cost effects should also reflect the lower number of years in which interest would be payable, the benefits of increased cash flow, any increase in salvage value after the shorter time period, and the cost effects of more frequent replacement of equipment with newer, more modern and more productive textile machines and technology.

Annualized capital costs represented about two-thirds of the RTI estimates of total annual costs for the 200 $\mu g/m^3$ level of control. RTI estimated separately the annual costs of manpower and supplies for operation and maintenance. These were often about 3 percent of the capital cost of control, though there was some variation among processes and sectors. The direct operating expenses accounted for about 6 percent of total annual cost for the 200 $\mu g/m^3$ level.

The Hocutt-Thomas estimates of engineering control costs for ATMI did not deal with annualized capital charges, but they did include separate estimates of annual operating, maintenance, and energy costs for controls. The only estimates clearly comparable to those of RTI, are the Hocutt-Thomas estimates of $3.7 million for maintenance of controls to achieve 500 $\mu g/m^3$ for the processes from opening through spinning. This is the same amount estimated by RTI. For energy, however, the Hocutt-Thomas estimate was $14.6 million a year (in 1977 prices), while the RTI estimate was $18.5 to $20.9 million (in 1975 prices) (Ex. 60 and Ex. 62, and IIS, pp. VI-16, V-17). Most of the changes from the proposal in this final regulation have cost reducing effects. The principal cost reducing change is the increase in the permissible exposure level from 200 to 750 $\mu g/m^3$ for slashing and weaving. In some cases of control costs this difference in cost as a result of the higher PEL is not assessed. However, in other cases of control costs, such as slashing and weaving, because the need for certain engineering controls and/or amounts of air and filtration would be changed costs were shown to be reduced significantly. For this reason OSHA has adopted the Hocutt-Thomas estimate for slashing and weaving which predicted a level of 1,000 $\mu g/m^3$ instead of the RTI estimate for slashing and weaving at 200 $\mu g/m^3$. Another provision with a cost reducing effect is the allowance of single use respirators. For all covered sectors the final regulation will be less costly than the proposed regulation.

For the textile industry, OSHA has set forth three alternate cost estimates. Table 1 shows the sums of the estimates presented for ATMI by Hocutt and Thomas, those presented by RTI, and the RTI estimates as adjusted by OSHA. RTI estimates for yarn production were higher than those provided by ATMI, even though RTI excluded twisting, winding, spooling and warping from their yarn preparation estimates. The initial RTI estimate, RTI-I on Table 1, was $984.4 million in capital costs for yarn production controls. The initial RTI estimate of annualized capital costs, reflecting the assumption of a 14-year depreciation period, was recalculated for Table 1 to reflect the shorter IRS depreciation period of 9 years; the estimate of annualized capital costs thus rose to a level to be compared with the Hocutt-Thomas estimate.

RTI noted that, if controls were not required for yarn production equipment used only to process synthetic fibers, the estimates for capital and associated costs would be reduced by 30 percent. That adjustment was made by OSHA to the RTI-I estimates to derive RTI-II estimates shown on Table 1. Even after that reduction, RTI-II capital costs were substantially higher than the Hocutt-Thomas estimate.

However, the RTI estimate of control costs for yarn processing, principally weaving, were much lower than the Hocutt-Thomas figure, which was not adjusted for non-cotton use. The difference between the $75.7 million Hocutt-Thomas estimate of capital costs and the $7.7 million estimate of RTI is largely attributable to the RTI assumption of compliance with the current regulation (IIS Table V-12, p. V-29).

For total industry control costs, both RTI-I and RTI-II, the initial and adjusted RTI estimates, are substantially higher than the Hocutt-Thomas figures prepared for ATMI. For the combined yarn preparation and processing costs, the Hocutt-Thomas estimate was $543 million in capital costs, compared to the $986.5 and $692.9 million estimates in RTI data. Because annualized capital costs dominate annual costs, the costs based on Hocutt-Thomas data, at $165.3 million, was also lower than either of those based on RTI data, $274.7 and $192.8 million. This was the case despite the increase in RTI estimates of annualized capital costs associated with the use of a shorter depreciation period, and reduction of energy and other costs in RTI-II.

B. *Costs for Other Provisions.* The regulation includes requirements on monitoring, medical surveillance, respirators, and work practices that affect costs. However, costs for these provisions are minimal compared to the costs entailed in engineering controls. Further some of the changes from the proposed regulation (e.g., use of disposable respirators) have cost reducing effects.

Except as indicated below, very little evidence on these provisions was given by industry. Therefore OSHA has relied primarily on RTI's estimates.

1. *Monitoring.* The final regulation permits use of alternative equipment for monitoring which is equivalent in accuracy to the vertical elutriator. While the development of such alternatives may be expected to lead to faster and easier delivery of monitoring devices and to easier and less expensive monitoring, such cost reductions were not calculated.

Figures developed by Dr. John Neefus of Burlington, indicates the industry cost would be $7.5 million a year for sampling using the vertical elutriator (Ex. 49).

RTI used the vertical elutriator to estimate costs in the IIS (IIS, p. IV-6). Total monitoring costs for yarn production and processing would be $5.63 million for capital and $.56 million for annual costs.

2. *Medical Surveillance.* RTI calculated separately the costs of each major provision of the medical surveillance program in the proposed regulation. Detailed estimates were presented for yarn production workers. These figures are set forth in the IIS Table B-Z page B-10. Costs were estimated at $22,421 a year for pre-employment testing; $13,835 for counseling, $48,925 for retest, $1,008,271 for periodic medical exams, $1,058,513 for equipment and $130,977 for training and total costs of medical surveillance for yarn preparation workers were $2,282,942 the first year and $1,093,452 annually. In some sectors there was testimony that RTI had used a monthly rather than an annual accession rate. Where this may have been the case, the result would be an underestimate of costs of pre-employment testing. Moreover, this would also mean that fewer employees would receive semi-annual retesting, so that the understatement of pre-employment test costs may be offset by an overstatement of retest costs as part of the medical program. However, the inclusion of the wage cost for the tested worker, which comprised one third of the cost per test, would not be applicable in pre-employment testing, and costs may be overstated on this account. Costs of informing certain applicants about their occupational exposure were calculated on the same basis, at $13,835 per year for yarn production companies. The same comments on accession rates, wages for tested workers and wage rates for those conducting the tests also apply to costs of informing the worker. Estimates of retest costs were $36,354 a year for yarn firms. costs of periodic reexaminations for continuing employees were estimated at $1 million a year if performed by a company nurse. Use of an outside contractor would cost $1.1 to $1.23 million a year for the yarn industry.

In addition, RTI estimated that each plant would buy a spirometer for $727.50, for a yarn industry capital cost of $1 million, and that nurses would be offered training courses in the use of the equipment for $131,000. These were included in RTI's estimate of $2.3 million in first year costs, in yarn production firms, and annual costs estimated at $1.2 million (IIS, pp. B-2 B-10).

Costs for the textile industry as a whole would include the yarn costs above and $.3 million for capital and $1.0 million for annual costs in weaving or a total of $2.6 million and $2.2 million, respectively, for the textile industry.

3. *Respirators.* Respirator costs calculated by RTI reflect allowance for the single use respirator. For Yarn production processes, annual costs were estimated for each level of permissible dust concentration for the periods before and after the installation of engineering controls for disposable respirators or for maintenance and materials for reuseable (half mask) respirators where they would be required. Costs of training in respirator use were also calculated. For yarn production, in a program using disposable respirators, these initial year costs were estimated at $18.5 million for 200 $\mu g/m^3$ exposure level. After controls are installed, yarn industry annual costs of disposable respirators would fall to $.91 million. For reuseable respirators, yarn industry costs would have been about 50 percent higher.

4. *Other Provisions.* RTI reviewed the cost of other provisions of the standard. RTI noted that informing the employee is required as part of the medical surveillance program and that training is required as part of the respirator program. Since those costs were estimated for those efforts, RTI said the additional costs of providing employee information and training and of filing reports on such programs would not be significant (IIS, p. B-48).

RTI estimates of posting (at $4 a sign) were, for the yarn producers, $79,668, $136,088 (IIS, pp. B-15-B-19). RTI also estimated the costs of specifying work practices for the yarn producing industries at $3.3 million in the first year and $14,774 in annual costs for ensuing years.

C. *Total Textile Costs—Conclusions.* There was no testimony that offered independent estimates for the textile industry of costs of compliance with the non-engineering provisions in the regulation. In order to compare estimates of total costs for the industry RTI estimates noted above for other provisions were added to the capital and annual cost estimates for engineering controls noted in Table 1. The results are in Table 2. The only costs excluded are initial year, non-capital costs for respirators and work practices.

For the industry as a whole, the Hocutt-Thomas estimates for all types of costs are lower than those of RTI, even after adjustment of RTI estimates by 30 percent for equipment related costs to exclude machines processing synthetic fibers only. Yet OSHA believes that the Hocutt-Thomas estimates of $550 million in capital and $171 million in total annualized costs are overstatements for several reasons:

(1) Compliance with the final regulation will be less costly than it would have been for the proposed regulation; (2) While OSHA did not have the data from the 1976 survey by ATMI, the equipment reported and estimated for retrofit control may have included some equipment which is used exclusively for synthetics; (3) While OSHA recognizes the validity of estimating compliance costs for retrofit controls, OSHA also recognizes the existing trend toward replacement of conventional machines with newer equipment which is more productive and produces less dust and which would lead to the predicition of fewer machines to be retrofitted or to be controlled; (4) While the costs to retrofit are based on currently and commercially available technology of controls, the estimates fail to reflect improvements in technology that are likely to continue during the period for compliance; and (5) RTI estimates of non-engineering provisions, such as for respirators and medical programs, did not account for

current spending toward compliance in existing programs in the industry.

For these reasons, though the ATMI estimates of compliance costs are lower than those offered by RTI, OSHA believes the ATMI estimates are on the high side. Since ATMI estimates are based on the most recent data, OSHA believes them to be more realistic than those offered by the IIS on the information available to RTI. However, since the ATMI estimates include some costs of compliance with the current regulation OSHA finds them to be overstatements of the incremental costs of this regulation. This is true to some extent for yarn preparation, and it is almost wholly true for the weaving costs shown because the exposure limit of this regulation, though stated in terms of respirable as opposed to total dust, is very similar if not higher than that of the previous regulation. Despite these qualifications however, OSHA recognizes that, in the absence of the ATMI survey data, OSHA cannot develop more accurate estimates of compliance costs. Therefore, OSHA's estimated costs of compliance, as stated in Table 3, are the Hocutt-Thomas estimates for capital costs and annualized costs plus the RTI estimates for costs of other provisions. Moreover, as noted below, OSHA finds that such costs can be borne by the industry.

OTHER COVERED SECTORS

In this section, the record evidence is examined separately for each of the other covered sectors, primarily the non-textile industries. Primary attention is given to engineering controls since the cost of other compliance provisions per employee in non-textiles industries approximate the cost of these activities for textile workers examined in the preceding section. For some of these industries, RTI did not have industry-specific data to assess costs, and for others only partial costs were reported (IIS, p. I-2).

A. *Waste Processing.* Several types of industries are engaged in the processing of by-products, including production of padding and upholstery fillings, garnetting of batting, production of nonwoven fabrics and surgical dressings, waste spinning, and bedding manufacture. Total costs for these waste processing industries were reported by RTI. The breakdown by industry classification reflected principal products of firms that may be involved in processes normally associated with other groups; for example, many bedding makers do the garnetting of their batting. As a result, while in other cases RTI assessments of economic costs may be related directly to industry testimony, in some cases RTI cost estimates may not be readily comparable with those offered in testimony.

Mr. Booker of NCCA said 19 plants in SIC 2294 (processed textile wastes mills) are processors of soft waste (Ex. 99E, pp. 16–18). NCCA then estimated installation costs of control at $13.6 million, at current prices, for the 19 plants, with costs of operation and maintenance (exclusive of power) at 2 percent of such costs, $273,000 a year, and energy costs of $237,000 a year. The report also noted that a number of workers would need respirators to comply with the proposed regulation after the installation of controls, and costs of that and other provisions were estimated on the basis of RTI methods, current wages or costs and survey results. As a result, the report indicated total capital costs of $13.648 million to achieve 500 $\mu g/m^3$, total direct costs of $.435 million for the first year and $.406 million for ensuing years. Annualized capital costs were $2.2 million at 500 $\mu g/m^3$ on the basis of the interest, depreciation and other cost assumptions used by RTI, and total annualized costs for the 19 plants were estimated at $2.8 million (Ex. 99E, pp. 18, 19, 25).

RTI used different methods for assessing costs of controls as stated in the IIS. RTI estimated installed costs at $3.8, $6.7 and $11.8 million for 500, 200 and 100 $\mu g/m^3$ levels, respectively (IIS, p. I-14). Thus, even the highest of these estimates, and consequently of estimates for annualized capital costs, was lower than that of NCCA, to achieve a higher predicted level of dust concentration. RTI estimated operating and maintenance costs at 3 percent of capital costs, while NCCA estimated them at 2 percent. NCCA also assumed reusable respirators would be required and current wage rates instead of the 1972 levels used by RTI. RTI's estimates of energy costs, from $.596 to $1.4 million a year, exceeded the $237,000 estimate of NCCA.

As a result of all of the differences noted above, the NCCA estimate of $2.8 million projected to attain 500 $\mu g/m^3$, for total annualized costs exceeded the $2.1 million RTI estimate to achieve 200 $\mu g/m^3$. Differences in control strategies and estimating methods played a major role in these differences, as did other differences in assumptions of price levels, in data available to NCCA but not to RTI, and the RTI inclusions of some costs of nonwoven fabric and spun yarn production. OSHA recognizes some reasons for costs higher than those estimated by RTI, such as estimating costs of reuseable respirators and price level differences, and feels that RTI estimates may then be on the low side. However, RTI did not exclude costs of compliance with the current standard from these estimates and did not assume such compliance for the waste processing industries, since there was some question on the part of RTI as to the applicability of the previous standard to these industries (IIS, p. V-8). Moreover, NCCA itself noted that estimates of costs of compliance with the proposed regulation might be overstated because they included control of equipment used exclusively on synthetic materials. In addition costs of compliance with the proposed OSHA regulation were commingled by NCCA with costs of meeting EPA requirements. Therefore while OSHA has accepted the NCCA estimates for the waste processing sectors, OSHA views the NCCA estimate as conservatively high, even for the high side of a possible range of estimates of compliance costs to retrofit currently used equipment, and recognizes that, with some technological adaptation, some machinery may be replaced by similar machinery used in the textile processes that generates less dust.

It is possible that firms listed as being in one SIC may be involved in several processes, some of which are likely to be in other classifications. While this was not likely to affect estimates for SIC 2294 (Processed textile wastes mills), it could affect some of the other waste processing and user industries. Garnetting, which may be done by certain waste processors for resale or by bedding manufacturers for use in mattresses and box springs included, although not exclusively, in SIC 2293 (paddings and upholstery fillings mills), and 2515 (mattress and bedspring mills). The RTI discussion of compliance feasibility for garnetting was included as part of the description for waste processing-batting, (IIS, pp. IV-16), IV-17), and the general conclusions noted above apply to this process, as well.

However, industry witnesses treated garnetting as a process separate from the other work of waste recyclers, in a separate section of the NCCA report (Ex. 99E) and with separate testimony.

Mr. Booker said there are 64 commercial and 120 bedding garnetters whose 1974–1975 output was 337.8 million pounds valued at $60.8 million. Engineering controls may achieve a dust level of 500 $\mu g/m^3$ in some areas, he said, but there is no knowledge of how to reduce concentrations to 200 $\mu g/m^3$ (Tr. 3508–3510, 3533). Installed costs for engineering controls were estimated by NCCA at $17.7 million, operating and maintenance costs for controls at 2 percent of capital, or $354,000 a year, and energy costs at $539,000 a year.

Costs of other provisions were also estimated as outlined in the NCCA report. The NCCA report estimated cost for these provisions for garnetting with assumptions and methods similar to those used for waste recycling. Capital costs of these provisions were estimated at $138,000 for medical equipment and respirators, so that the total

capital cost, including controls, was $17.8 million. Operating and maintenance costs for these provisions were estimated at $472,000 for the first year and $294,000 a year for ensuing years. The annualized capital charge was $2.8 million; direct operating costs for all provisions $648,000 and energy costs, $539,000, so that total annualized costs were $4 million.

RTI had estimated costs for SIC 2293 and 2515 equipment controls jointly. However, in the absence of survey data available to NCCA, assumptions on machine productivity were related to output data for the RTI estimates of the equipment, and RTI estimated the number of garnetts as 481 instead of the 608 estimated by NCCA. RTI also calculated separately the costs of and estimated 240 pickers (not included by NCCA), used with the garnetts.

There was no industry testimony on the costs of compliance in for bedding manufacturing processes beyond garnetting. This is part due to garnetting existing outside SIC 2293 and 2515. RTI estimates for SIC 2293 and 2515 combined may be expected to be comparble to the industry estimates for garnetting. RTI estimated capital costs for the firms in these two classifications at $13.4, $26 and $44.3 million for 500, 200 and 100 $\mu g/m^3$ dust levels, respectively. Annualized capital costs estimated for these levels were $2.2, $4.0 and $7.1 million; annual operating costs were $2.5, $2.8 and $3.1 million; energy costs were $1.9, $2.9 and $6.8 million so that total annualized costs were $6.6, $10.7 and $17 million (IIS. p. 1-14).

These SIC 2293 and 2515 combined estimates of RTI, were substantially higher than those of NCCA for garnetting. NCCA indicated that they could not predict dust levels below 500 $\mu g/m^3$. The NCCA estimate of $17.8 million for capital costs was substantially higher than the RTI capital costs estimate of $13.4 million for a level of 500 $\mu g/m^3$. The NCCA estimates of operating, energy and total annualized costs were lower than RTI's for that dust concentration. Both estimates were presented as reflecting orders of magnitude, and since there were differences in price levels and underlying data as well as in control strategies it is difficult to compare them.

Because of these differences in the nature of the NCCA and RTI estimates, it may be possible to view them as alternatives in an range of possible total costs of compliance for the waste processing industries. RTI reports such a total for SIC 2293, 2294 and 2515 as $32 million to achieve 200 $\mu g/m^3$ (IIS. pp. 1-14, 1-15, V-39). This total may be comparable to the sum of costs for waste recycling and garnetting estimated by NCCA (Ex. 99E, pp. 25, 54, 55). The NCCA estimate of total capital costs was $31.5 million, primarily for engineering controls that NCCA said could achieve 500 $\mu g/m^3$, but could not achieve 200 $\mu g/m^3$. This estimate was almost the same as the $32 million RTI estimate to achieve 200 $\mu g/m^3$. Since the goal of the NCCA control strategy was to comply with the 200 $\mu g/m^3$ level of the proposed standard, these estimated can be viewed as being the same costs with major difference being the assessments of NCCA and RTI of the technological feasibility of such control costs to achieving the 200 $\mu g/m^3$ exposure limit of the proposed standard. OSHA has accepted NCCA's estimate of 31.5 million. Variations in methods, data available assumptions made by NCCA and RTI did not lead to substantial differences in estimates of capital spending. RTI included some additional areas of control (nonwoven fabric and waste spinning). However, the RTI estimate was in 1974 dollars, while the NCCA estimates were in current prices for controls. This difference might be about 7.5 percent. Such differences were probably offsetting ones.

RTI and NCCA used the same assumptions in determining annualized capital charges. Therefore, differences in total annualized costs stem from differing estimates of energy requirements and costs and direct operating costs. Where RTI assumed that these costs for controls are 3 percent of capital spending, NCCA estimated them at 2 percent. These differences lead RTI to estimate total annualized costs at $7.9 and $12.8 million for 500 and 200 $\mu g/m^3$ respectively, while NCCA estimated total annualized costs at $6.9 million (for 500 $\mu g/m^3$). Since the greatest difference was in energy costs, and since NCCA based its finding on current surveys of producers that included data on costs and locations, OSHA views the NCCA estimates of energy costs as more likely to represent the actual costs to these firms and industries. Since the energy rates used were cited by NCCA as likely to be low for only some locations, OSHA feels that NCCA may not have underestimated such costs by very much, and that total annualized costs for the waste industry are about $7 million.

The NCCA report (99E pgs. 32-34, 58-9) notes that internal cash flow would be inadequate to finance control costs and that external financing may be difficult for some waste recyclers such as small firms. This would be true to some extent for the garnetters as well, though NCCA indicated that there were less financial data for garnetting to justify that conclusion and that some garnetters, as divisions of larger firms, could obtain financing. However, NCCA's conclusion on the problems of capital financing are based on the assumption that costs for compliance would be absorbed by the firms and that profits would be reduced to that extent. RTI, on the other hand, assumed that profit rates would remain at current levels and that costs would be shifted. While some, especially the smaller independent firms, may have greater problems in obtaining financing it should be noted that the capital charges were based on a 10% interest rate (a higher rate than used in some other OSHA regulatory cost estimates), with additional costs for overhead, taxes and insurance at 2.5%. These rates are comparable to those cited by the U.S. Small Business Administration for debt costs of 7 year term loans at 10% and 5 year term loans at 12% for small firms. (Addendum No. 2).

B. *Cottonseed Processing.* Much of the testimony on cottonseed processing questioned the feasibility of the proposed standard and predicted dire economic effects including a substantial number of plant closings. Two reports were submitted by the National Cottonseed Products Association, Inc. (NCPA); a report of the Texas Agricultural Experiment Station of Texas A & M University, "Design and Cost of Lowering Dust Levels in the Working Environment of a Typical Cottonseed Oil Mill Processing 200-225 Tons per Day," (Ex. 93i), and a report by Development Planning and Research Associates, Inc., "The Economic Impact of Proposed Cotton Dust Standard on the Cottonseed Processing Industry."

Fred Husbands, executive vice-president of NCPA, said 83 mills were in operation in 1976, and most of the firms would be characterized as small businesses. He said four products are made: seed linters, kernel meal, hulls, and edible oils. All are freely substitutable with other products, such as soybean oils, in competitive domestic and world markets.

RTI reported that they did not view the industry as being subject to the previous standard and therefore did not assume industry compliance with it (IIS). Dr. Calvin Parnell of Texas A & M University was principal author of the design report on technological feasibility. The design goal was reported to be to obtain the lowest feasible dust level using the best available technology with attempts to minimize costs where possible (Ex. 93i, pp. 305). The design study estimated the total costs for required equipment and its installation at $612,125 and annual costs of controls at $357,826 for the four processing areas of a mill processing 200 to 255 tons per day. Excluded were costs for controls in the seed house (Ex. 93i, p. 62).

The economic impact report developed an estimate for industry-wide cost of compliance by extrapolating

Parnell's cost to the four size categories of plants drawn in the economic impact study: small, medium, large and extra-large. "Retrofit costs," identified as costs of building modification, rearrangement of production facilities and electrical modifications, were added to the costs associated with Parnell's engineering design.

Total investment costs were estimated at $75 million, including $46.3 and $28.5 million for equipment and retrofit installation respectively, and $130,000 for capital costs of other provisions of the proposed regulation not related directly to engineering controls (Ex. 93i, pp. 11-3—11-5, VII-1—9).

Costs of control were initially estimated in terms of 1976 prices and were then deflated by 8.5 percent to be in terms of 1974 dollars, the terms of estimate used by RTI.

RTI estimated costs for some specific controls or steps, but was unable to obtain data on equipment or equipment capacity from published literature or industry sources. As a result, RTI could not estimate costs of engineering controls or of associated operating, maintenance or energy requirements. RTI did estimate the costs of other provisions of the proposed standard at $.31 million in capital, $.5 million for first year operating costs and $.44 million for annual costs in ensuing years (IISs pp. AA-46, IV-21, V-38, V-39, and V-41). RTI estimates for these costs were the ones used by industry sources, in their presentations (Ex. 93i, p. VII-9).

Other elements of the industry calculation of annual costs included an estimate of the value of production loss, attributed generally to loss of efficiency, as a result of controls at $8.6 million a year. Other elements of annual costs included operating, maintenance and energy costs of $7.7 million, average interest on investment of about 6 percent of capital, or $4.5 million, and depreciation for about 15 years, at $5.35 million. Total annual costs for the industry were estimated at $26.7 million (Ex. 93i, p. VII-9).

Donald Wiseman, vice president of the firm which prepared the economic impact study for NCPA, said the estimates of cost were on the "conservative side" because, in the absence of estimates for engineering controls for the seed house, such costs were excluded. The predicted impact included the potential closing of 62 of the 83 mills, principally the smaller and medium sized older plants, representing 52 percent of the capacity of the industry. This estimate was based on cost estimates and financial profiles of the model plants which indicated that the $75 million estimate of capital costs represented about 8.5 times the average annual investment of the industry. Mr. Wiseman said average annual profit of small and medium size firms was less than 2 percent of sales, but these firms would need price increases of 3.1 to 3.5 percent to retain present profit margins.

The costs could not be passed forward, he said, because industry shipments of cottonseed products represent a small proportion of the principal products (edible oils and animal feed) which are sold in competitive markets. Passback of costs through gins to farmers is not feasible either he said, because farmers, with competitive pressures from other crops and with other impacts from the proposed regulation, would contract supply. If some plants leave the industry, he said, others may have excess capacity, but there would be a rise in distribution and hauling costs to the more distant, remaining firms. Thus the estimate of shutdown was based on the ability of the 83 firms to absorb and finance projected compliance costs (TR 3420-3427, 3347-3351).

OSHA agrees that it is unlikely that cottonseed processors will be able to pass added costs forward to buyers of their output. In competitive markets, with substitutes from other sources, demand is very elastic and changes in the industry's output or product supply are not likely to effect significant changes in product prices. However, since seed is a fiber byproduct, input supply for the industry is likely to be very price inelastic (amount of seed available generally remains the same regardless of price). Seed prices are subject to modification and costs as reflected in reduction of seed prices can be shifted forward by the fiber producers to the buyers of their main product, raw cotton. Indeed, the working assumption of the industry was that there would be such cost shifts (Tr. 3609-10, 3620-23). However, the magnitude of such an impact will depend in large part on the actual costs of compliance incurred by the industry.

Though the RTI cost estimates for non-engineering provisions were accepted for use in the industry study, Dr. E. D. McMurrain said the Buckeye division already had a medical surveillance program involving physical examinations and pulmonary function tests (Tr. 3396, 3397, 3410). Other members of the industry panel said they did not know how many mills had surveillance programs. To the extent that firms do already have programs related to provisions of the proposed regulation, this would reduce estimates of incremental costs of compliance.

Further, the engineering costs of the model plants reported in the economic study were higher that those reported in the design study. Total investment costs for the design study's model plant producing 200 to 255 tons per day were estimated at $612,125, including installation, in 1976 prices (Ex. 93i, p. 62). The economic study's medium size model plant, producing 216 tons per day, was estimated to have $520,306 in equipment costs and $284,000 in retrofit installation costs, or a total of $804,306 in capital costs of controls, in terms of 1974 dollars (Ex. 93i, p. VII-9). After adjustment for price level differences, the estimate of control costs for the medium sized plant in the economic study was more than 40 percent higher than the estimate of such costs in the design study, though both excluded costs related to dust control in the seed house. The difference in these estimates is the additional cost attributed by the economic study to "retrofit costs," identified as building modification and other costs. While Parnell said at the hearing tht he disregarded costs associated with the implementation of his theoretical engineering design to existing oil mills (Tr. 3400-01, 3415-16), and his cost tables do not appear to reflect any such costs except possibly in the costs estimated for installation of equipment, the specifications for his design study clearly include such measures as enclosing the mill and sealing and isolating areas such as the cleaning room (Ex. 93J, ppl. 12, 13, 14, 15, 20, 22, 26, 44, 59). To the extent Parnell's cost projections do in fact include elements costed again in Wiseman's figures, the latter figures are overstatements, but in the absence of further justification and breakdown of these costs by the industry, OSHA is unable to discount this estimate by any percentage.

Moreover, while Parnell declined to predict the dust levels achievable under his design, its aim was compliance with the proposed standard whose ultimate goal was the 200 $\mu g/m^3$ level. As such, OSHA expects that costs for achieving the 500 $\mu g/m^3$ level would not be as great.

The projected production losses, of $8.7 million, accounted for nearly a third of the industry's estimate of $26.7 million in total annual costs. Production losses was only generally identified as reduced efficiency with the installation of controls such as oil and lint loss and cellulose yield reduction (Ex. 93i, p. VII-3) and Mr. Wiseman could not supply any further breakdown at the hearing (Tr. 3421). It should be noted that Parnell's design study did include instances where the choice of controls and their design was based on the need to maintain efficiency (Ex. 93J, pp. 14, 30, 44, 50). To the extent that production loss has already been considered in the design study, the estimates in the economic impact study would be overstated. Further, industry testimony reflected an existing secular decline in the number of oil mills and projected

that a new regulation would accelerate shutdowns in the industry. However, these industry estimates of compliance costs were based on the assumption that compliance costs would apply to all 83 firms. If a large percentage of mills are expected to cease operations, then compliance costs must be reduced by that percentage.

For these reasons, though there are no other estimates of industry-wide costs, it appears to OSHA that the estimates of $75 million for investment and $26.7 million for annual costs are high, even for the best available technology and even as a highside estimate. Given time for development and implementation, lower cost technology may be developed to permit control costs under those of the industry's design study and to reduce any projected production losses.

OSHA also believes that a figure of 75 percent as the number of mills which would close rather than incur the costs of compliance is very high. However, to the extent that the existing secular decline in the number of mills continues and is accelerated by the costs of complying with the 500 $\mu g/m^3$ regulation, the industry estimate overstates the prediction of the capital costs of compliance by including the costs of all 83 firms presently in operation.

The economic impact study concluded that 62 of the 83 mills are likely to close as a result of the added costs of cotton dust regulation. However this conclusion is based on two assumptions that do not appear to be realistic: (1) that none of these costs can be shifted and (2) that costs and revenues will be constant over the next 20 years (Tr. 3421-22). As noted above, even if competitive pressures will prevent product price increases, some shift in the form of reduced imput prices is likely to occur. As long as fiber is ginned and byproducts such as seed are produced, fiber producers will sell byproducts for any price they can get. To the extent seed prices decline, the amounts would be absorbed in fiber prices rather than in seed mills. The industry assumption was based largely on the anticipated effects of the proposed regulation on ginning. However the final regulation differs substantially from the proposed regulation and compliance costs for gins are now calculated to be on the average of $659 per gin in the first year and $612 annually thereafter, costs which will not result in the economic disarray the economic impact study for cottonseed processors had anticipated. Moreover, the industry as a whole clearly anticipates cost shifts through the fiber producer from the cotton seed processors (Tr. 3609-10, 3620-23).

As a result it is not reasonable to project continued costs and revenue patterns over 20 years as a basis for predicting shutdown of firms. To the extent that compliance costs are offset by reduction in costs of raw materials, the firms would remain sufficiently profitable to warrant investment of internal funds where available or from external sources by borrowing. The industry report indicates a number of reasons why such closures might not occur despite economic pressure (Ex. 93i, pp. II-6, II-7) and also notes that the primary reason for past closings has been a shortage of cottonseed for processing (Ex. 93i, p. III-1). The large number of predicted shutdowns appears unlikely as long as there is a supply of seed which, as a byproduct, must be considered as being inelastic in supply.

Some firms which may experience losses or may apparently be marginal in their profit position may decide to close. OSHA does not view such closings necessarily as a result of regulation in view of secular decline in the number of oil mills over the decade.

C. *Knitting.* While RTI estimated about 168,000 production and maintenance workers in knitting firms may have some exposure to cotton dust in their normal activities, this industry, covered by the proposed regulation, was omitted from the RTI study for lack of adequate data (IIS, p. 1-2). Testimony for the knitting industry was presented, but costs of compliance were not estimated, either in that testimony or by RTI, for the knitting process. R. L. Thistlewaite of the National Knitwear Manufacturers Association said that some firms in the knitting industry make yarn but testimony on yarn production processes had been presented by ATMI and AYSA (American Yarn Spinners Association) Association members knit, cut and sew apparel.

Mr. Thistlewaite said the effects of very large compliance costs could depress sales at the retail level, which are subject to foreign competition. If cotton costs are too high, knitters will have to switch to synthetics or to foreign sources where regulatory costs are lower.

Since the final regulation provides for a higher permissible exposure limit (500 $\mu g/m^3$) for knitting and there is evidence in the record of existing low levels in knitting, OSHA does not feel that the costs of engineering controls will be significant for the knitting processes. However, these firms would be likely to encounter the minimum costs of medical surveillance, monitoring and other requirements of this regulation.

D. *Classing and Warehousing.* Warehouses, classers and shippers are not expected to require significant engineering controls as a result of the increase in the maximum exposure level to 500 $\mu g/m^3$ in this regulation. A sample of existing exposure levels indicates most facilities meet 200 $\mu g/m^3$, and few readings were in excess of 500 $\mu g/m^3$. The capital and other expenditure requirements can be met because of the present low levels, and few significant costs, other than those for medical programs are anticipated under this regulation.

RTI did not estimate compliance costs for classing or warehousing. Industry sources used methods similar to those developed by RTI for yarn production. However, industry estimates included $1.27 million for development of written programs for work practices for each of 31 positions in each of 377 warehouses, for a total of 11,687 positions analyzed for a total of 14,500 workers. The 11,687 positions were multiplied by the cost per hour to develop these programs for a total of $1.2 million. To this NCCA added $67,041 in first year training costs. OSHA does not accept that every worker function in every warehouse has to be analyzed separately. Work practices for warehouses can be developed according to the same models used by NCCA in their economic report. This would mean 186 positions for a total of $19,358 to which OSHA has added the NCCA training cost of $67,041 to get $86,399. In addition, NCCA estimated $6.8 million a year in recurring costs, or more than two-thirds of the estimate of annual costs, for monitoring. This estimate assumed sampling stations for each 1,000 square feet, or 233 stations per warehouse times 377 warehouses. However, this regulation requires sampling for each major work area. The $6.8 million for monitoring estimated by NCCA has been adjusted by OSHA to relect the actual number of sampling sites (12,161) and total cost $851,271. The annual costs to the industry are a total of $1.4 million: NCCA's estimate for recurring workpractice costs of $28,000, OSHA's monitoring estimate, $851,000, OSHA's estimate for single use respirators, $222,000 and OSHA's estimate of workpractice and training costs, $86,399.

E. *Total compliance Costs.* Estimates of costs of compliance for the principal industry sectors and the major cost-related provisions of the regulation are summarized in Table 3. In most cases, OSHA has reviewed and accepted the bases of the cost estimates presented in industry testimony, though these have sometimes been adjusted. OSHA's final estimates are conservatively high. However, they are sometimes lower than those presented by RTI.

A. *Capital Costs for all covered industries.* OSHA has estimated capital costs for all affected industries at $656.5 million, with the bulk of these costs, $543 million, for engineering controls in yarn production and processing in the textile industry. OSHA

adopted industry's estimate for capital cost in the textile industry. OSHA's estimate of $31.5 million in capital costs for waste processing is the sum of the estimates of NCCA for the recycling and garnetting processes. The industry estimate for seed processing capital requirements was $75 million.

OSHA anticipates that no engineering controls will be required in warehouses. Capital may be required for monitoring, or medical programs, but only to the extent that such programs do not already exist or are not provided by contracting services. It is OSHA's view that this will be true also for the knitting operations and other industrial sectors for which estimates were not presented.

OSHA recognizes that this estimate of total capital costs may be viewed as a substantial one. However, as is indicated below, it is within the financial capability of these industries to bear these costs.

B. *Total Annualized Costs.* Total annualized costs as noted above, include the maintenance, operating and energy costs of all provisions as well as the interest, depreciation and other charges associated with the installation of engineering controls. The total annualized costs for the textile industry ($171 million) as for other industries, are dominated by the annualized capital cost ($109 million). These total annualized cost of $171 million a year for all provisions, were based on industry estimates of capital required and industry assumptions on annualizing capital charges, but on RTI calculations of the costs of other provisions.

The estimate of $6.9 million in total annualized costs of waste processing was taken from industry testimony, as noted above. For the seed mills, however, the industry estimate of annualized costs was $26.7 million.

Although for warehouses it is anticipated that there will be little need for engineering controls, there will remain costs of other provisions such as medical and monitoring programs. Such costs it is anticipated will not exceed the $1.5 million reported in Table 3. Thus the sum of total annualized costs is estimated at $206.1 million for the principal industries covered by the regulation.

OSHA believes this to be a conservatively high estimate of the current costs of compliance with the final regulation. OSHA estimates do not assume, for either the textile or nontextile industries, compliance with the current standard. Although record evidence established that some operations are in compliance with the permissible exposure limit of the previous regulation, and indeed that some operations have already achieved or are close to achieving the permissible exposure limit of this standard, it could not be determined to what degree particular permissible exposure limits had been met and by what proportion of the various industry sectors. Moreover, except in the case of textile industry investment in controls, OSHA's estimate of total annualized costs does not account for current industry spending for programs that will achieve compliance. The record indicates that some employers are already conducting medical surveillance programs and furnish employees with respirators.

OTHER ECONOMIC IMPACTS

The estimate of total annualized costs is important in assessing the economic impacts of the regulation. These costs are assumed to be the passed through to those who consume fiber products. As a result, changes in price levels and other impacts are directly related. Less directly related are effects on industry structure, production and employment.

In the IIS (Section VI of Volume I) RTI analyzes in some detail the economic effects of the proposed cotton dust standard for different exposure limits. The analyses are done separately and in greater detail for the yarn producing industries, and they are then reported for other covered cotton processing industries before they are summarized for the total industry effect.

A. *Additional Manpower.* The regulation will require the employment of additional manpower in order to provide for the maintenance and operation of engineering controls and for the implementation of non-engineering provisions, such as the medical surveillance, respirator and monitoring programs, and to offset any changes in labor productivity.

RTI projected that the 200 $\mu g/m^3$ standard of the proposed regulation manpower requirements could easily be provided by internal or regional labor supplies except for the very highly skilled. The impact on wage rates was termed negligible since the change was less than 1 percent of current employment and since there are continuing additions to the labor force (IIS, pp. VI-122-123).

On the basis of the conclusion by RTI, it is clear that the final regulation will have less of an effect than the "minimal" and "negligible" ones associated with proposed 200 $\mu g/m^3$ standard for several reasons one of which is that the amounts of controls requiring maintenance will be less.

B. *Energy.* There are two types of effects on energy consumption that could result from the regulation. One, noted by G. C. Cortwright of the Industry-wide Byssinosis Committee, would occur in the substitution of other fibers, principally synthetics derived from petroleum, for cotton which is an annually renewable fiber which uses much less energy than any other source per unit of fiber (Tr. 2617-2622). RTI did not analyze this type of energy effect, but instead concentrated on the increased use of energy for providing power for the engineering controls required by the regulation.

The estimated energy costs of the final regulation are less than a third of the estimates of RTI for the 200 $\mu g/m^3$ level. On that basis, the impact on the national energy situation would be even less than the estimate of RTI; it would affect about 0.018 percent of national energy consumption, by application of that percentage to the RTI estimates. It still would be significant for the industries involved, especially the textile industry. RTI estimated energy costs for yarn production and weaving at $154.2 million a year for the 200 $\mu g/m^3$ level (IIS, p. I-15). The estimate in industry testimony related to the final regulation for textile industry was $49.0 million. Thus the estimated effect on the textile industry, the principal user of added energy, would be much less under this final regulation. Since a much smaller proportion of the total extra energy use is in other sectors, it is reasonable to conclude that there would be no appreciable impact on energy use as a result of the final regulation.

C. *Capital requirements, Financing.* RTI noted that, even if it is assumed that there will be no impact on profits because costs are passed on and the rate of return in investment is maintained for the same profitability, the availability of capital financing could be a problem in compliance with the cotton dust regulation. There might be capital shortages, and the need for funds could, RTI said, have impacts on regional and national growth since less capital might be available for replacement of obsolete equipment and expansion of capacity to the extent that capital is invested in controls. However, it was noted that the existence of excess capacity in the industry indicates that there would be no severe shortages of capacity as a result of the capital requirements for compliance. The extent of the impact of capital requirements and availability, RTI said, would depend on how they are financed, the time permitted for compliance and the interest rate.

Over the past 10 years, Fitzgerald said, the industry has tended to finance capital spending through internally generated funds, since it has been difficult to raise funds externally (TR 2746). Arthur Figh, vice president of Chase Manhattan Bank agreed. He equated the RTI control costs estimate with four years of after-tax profits. He said the control investment costs would be passed on to consumers ultimately, but textile industry earn-

ings are likely to remain at about half of the profit level of industry generally, so that there was a question of viability of some firms with greater burdens, especially older and smaller ones competing with newer plants with lower costs. While the investment in the industry has exceeded depreciation, a situation that is not unusual, some of the firms have higher profits (TR. 2566-2517).

RTI noted that industry analyses of issues on capital availability were less valuable because the financing issues related to individual companies, and each industry was a heterogenous group of firms. The rate of return on investment varies with the size of firms, as does the level of profits after taxes, RTI said, with some, especially among the smaller firms, having losses. (RTI assumed that there was no significant variation in capital and compliance costs per unit of output and therefore expected none in profit levels before and after compliance that would be attributable to firm size. This was reasonable under the RTI assumption overall that there was compliance with the current standard; it may not be true if, as in the regulatory cost estimates which do not assume current compliance, the smaller firms have invested less in controls than the larger firms have.)

Ratios of capital requirements to after-tax profits were used by RTI as guides to the availability of capital financing. After-tax profits were used only as an indicator, since the capital expenditures will themselves affect tax levels; through any investment tax credit and cost recognition, such expenditure would reduce tax levels for firms with profits. However, after-tax profits may serve as guides to the availability of funds for internal financing of capital requirements and determine eligibility for borrowing, as evidence of ability to repay funds obtained from external sources. RTI found these capital-profits ratios higher in each industry for the smaller firms. (The implications of this finding on market competition are discussed in the next section). RTI examined a number of firms and found that, for capital requirements of the proposed 200 $\mu g/m^3$ standard, capital expenditures were three times the annual after-tax profits for all firms in the weaving sector, with more than $500,000 a year in sales. For the same 200 $\mu g/m^3$ level for yarn firms the range was from 2.19 to 5.51 of the capital after-tax profit ratios for companies with sales in excess of $500,000 a year. There was great variability in the ratios of the smaller firms with sales under $500,000 a year.

RTI provided an anlaysis in detail for 35 publicly owned firms. RTI noted that, while the financial impact was high for the 200 $\mu g/m^3$ level, it was much less for the 500 $\mu g/m^3$ level, which would be "manageable" for all but the smallest firms (This analysis is reported in IIS, pp. VI-41-54, 95-99 and 127). In testifying on these effects, however, Dr. LeSourd of RTI noted that implementation of the proposed standard would require adjustments within the cotton textile industry and might be difficult for many firms but that in time there would be rising prices and market adjustments so that revenues would cover costs. Although the impact on any one firm cannot be predicted, he said, nothing in the RTI study showed that the cotton industry as a whole would be threatened by the impact of the proposed 200 $\mu g/m^3$ standard (TR 561-563).

For several reasons, the impact of the final of the final standard will be much less severe than the effects described by RTI for the 200 $\mu g/m^3$ standard. Estimates of capital costs are less than half of the estimate of RTI for the 200 $\mu g/m^3$ level. As a result, on the average, the captial-profit ratios estimated by RTI would be expected to decline dramatically.

RTI notes that the severity of the financing problem would be relieved with additional time for achieving compliance. That may be the case, but only if firms are not inclined to wait until the end of the period allowed to arrange the financing of controls.

It is OSHA's conclusion that although some marginal employers may shut down rather than comply, the industry as a whole will not be threatened by the capital requirements of the regulation, which are far less severe than the proposed 200 $\mu g/m^3$ standard. As noted above, concentration into larger firms is a trend which currently exists in the cotton industry and which is not attributable to OSHA regulation. OSHA is confident that the productive capacity of the surviving firms in the affected industries will be able to meet the demands for production of cotton products.

Difficulties of financing capital costs in non-textile sectors would be limited to the waste recyclers and cotton seed processors since those sectors are the ones that will be required to make major investment in engineering controls. While OSHA recognizes that the expected capital costs are major and will present more difficult problems than in the textile sectors, OSHA concludes that industry assessments of the effects of such problems have been adjusted when allowance is made for the predicted ability of these firms to pass increased costs back through the fiber producers and for the negligible economic impact which the final standard, as opposed to the proposal, will have on the ginning industry. With these important factors is mind, OSHA believes that the capacity of these sectors to bear the costs of compliance is far greater than the industry's assessments would indicate. This is not to say that OSHA expects every firm to survive; indeed the clear trend of secular decline of the number of firms establishes that not all closings will be attributable to this regulation. However, OSHA's statutory mandate does not guarantee that the costs of regulation will never lead to the shutdown of marginal firms. In light of all these considerations, OSHA concludes that the standard as applied to these sectors as a whole will not threaten their economic viability and thus is generally feasible.

I. *Benefits.* The legislative history and language of the Occupational Safety and Health Act, as distinguished from some other environmental and safety legislation, clearly indicate that Congress has already arrived at a judgment concerning the balancing of cost and benefit, with the result that worker safety and health are to be heavily favored over the economic burdens of compliance. Specifically, Section 6(b)(5) of the Act provides that:

> "The Secretary in promulgating standards dealing with toxic materials or harmful physical agents under this subsection, shall set the standard which most adequately assures, to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life. Development of standards under this subsection shall be based upon research, demonstrations, experiment and such other information as may be appropriate. In addition to the attainment of the highest degree of health and safety protection for the employee, other considerations shall be the latest available scientific data in the field, the feasibility of the standards, and experience gained under this and other health and safety laws".

Thus, while feasibility is an appropriate consideration, the Secretary is directed to set standards which attain the "highest degree of health and safety protection for the employee * * *".

This does not mean, however, that a systematic evaluation of costs and benefits is not to be encouraged within the limits of the estimation techniques. In considering the issue of feasibility in this rulemaking, as in others, OSHA has carefully evaluated the cost of compliance which may be incurred by the directly affected employers and their ability to comply. Additionally, OSHA believes that a standard for a substance which has been found to pose a risk of chronic obstructive pulmonary disease to workers must assure maximum benefit (i.e. prevention of serious illness or death), constrained only by the limits of feasibility.

There is overwhelming scientific evidence that cotton dust produces adverse health effects among cotton workers. The disorders range from an acute reaction manifested by a depression of pulmonary function indicators, or by subjective symptoms such as chest-tightness, shortness of breath, or cough, chronic obstructive pulmonary disease.

The epidemiologic studies discussed in the proposal, and in this preamble (see Health Effects and Permissible Exposure Limits sections) give an indication of the adverse health effects which will be significantly reduced by this standard. The work by Merchant et. al. represents the most thorough and objective evaluation of byssinosis prevalence in the United States textile industry. The Merchant study of approximately 3,000 workers employed in 8 cotton and cotton-synthetic blend mills found a strong linear association between the prevalence of byssinosis and the concentration of lint-free respirable dust as measured by vertical elutriator. In cotton preparation areas Merchant found a byssinosis prevalence 1 of 7 percent (all grades) at 100 $\mu g/m^3$, 13 percent at 200 $\mu g/m^3$, 26 percent at 500 $\mu g/m^3$ and 50 percent at 1700 $\mu g/m^3$.

Research Triangle Institute (RTI), OSHA's contractor for the inflationary impact statement, estimated the number of cases of byssinosis (all grades) that might be expected currently among yarn production workers by job classification. The number of cases that would be expected to occur if current exposure levels were reduced to 500 $\mu g/m^3$ and 200 $\mu g/m^3$ TWA were then estimated to provide an approximation of the direct benefits that would result from compliance with these alternative exposure limits. RTI estimated that compliance with 500 $\mu g/m^3$ and 200 $\mu g/m^3$ would lead to the avoidance of 103 and 388 cases of byssinosis (all grades) per year in the yarn preparation areas.

The RTI estimates of byssinosis cases avoided per year suffer from serious methodological problems.

The annual rate of new cases is derived through a formula which seeks to translate point prevalence estimates into an annual incidence rate estimate. A relatively simplistic formula which uses the new hire accession rate in the textile industry is used as the translating mechanism.

There is no epidemiological study of incidence of byssinosis and any attempt to translate point prevalence estimates into annual incidence estimates is fraught with numerous methodological problems.

The population estimates of the yarn industry used in the study, 126,423 is an underestimate. A more accurate estimate would be in the area of 200,000.

The point prevalence estimates themselves understate the problem in that there is a natural exodus of workers afflicted by acute respiratory symptoms.

Perhaps most damaging is the incorrect use of turnover data, the key translating mechanism to annual rate incidence. The RTI study used 5% as the annual turnout rate whereas, in fact, it is a monthly figure. Were all new hire accessions to be new entrants into the industry, the yearly turnover rate would actually be 60%. This, however, would be an overstatement as there is considerable turnover of workers within the industry. A reasonable though conservative estimate would be in the neighborhood of 20% per year.

(3) Using the RTI methodology, the following estimates were generated:

$$Ca = wA\,(Pc - Ps)$$

where Ca = cases byssinosis avoided per year

w = number of workers
A = labor accession rate
Pc = current prevalence rate of byssinosis
Ps = prevalence rate of compliance with specific dust standard

For a 500 $\mu g/m^3$ standard in yarn preparation

$$Ca = (200{,}000)\,(0.20)\,(0.25 - 0.1655) = 3380 \text{ cases/yr.}$$

For a 200 $\mu g/m^3$ standard

$$Ca = (200{,}000)\,(0.20)\,(0.25 - 0.1274) = 4904$$

Grover Wrenn of OSHA noted at the outset of the hearings on the proposed regulation that decisions on standards are not based primarily on benefit-cost analysis. In their post-hearing statement, however, the council on Wage and Price Stability advocated cost-benefit analysis as the basis for determining the exposure limit for each sector and provided examples of reasoning in a theoretical model. That model assumed a ceiling amount, as the most the industry could afford, to be spent for compliance costs and indicated the marginal basis for allocation of such expenditure. However, OSHA has no desire to be punitive or to impose on industry all that it could afford; OSHA's goal is to protect worker health and to determine the technological and economic feasibility of the measures required to effect that purpose.

OSHA cannot place a specific value on a case of byssinosis of any grade. OSHA is confident that industry will find more efficient. less costly controls than those estimeted over the period for compliance partly as the result development of new technology in controls and in production processes. OSHA believes as indicated by the RTI studies, that the industry would not be threatened by such costs, while the health of the worker would be threatened by the failure to incur them.

Based upon the foregoing and the record as a whole, OSHA finds that compliance with the standard is well within the financial capability of the covered industries. Moreover, although the benefits of the standard cannot rationally be quantified in dollars, OSHA has given careful consideration to the question of whether these substantial costs are justified in light of the hazards of exposure to cotton dust. OSHA concludes that these costs are necessary in order to effectuate the statutory purpose of the Act and to adequately protect employees from the hazards of exposure to cotton dust.

In making judgments about specific hazards, OSHA is given discretion which is essentially legislative in nature. In setting an exposure limit for a substance like cotton dust, OSHA has concluded that it is inappropriate to substitute cost benefit criteria for the legislatively determined directive of protecting all exposed employees against material impairment of health or bodily function. Where the health effectiveness of alternative approaches are extremely uncertain and likely to vary from situation to situation, OSHA believes it is appropriate to adopt the compliance strategy which provides the greatest certainty of worker protection even if the approach carries with it greater economic burdens for the affected employers.

In the case of the cotton dust standard, the evidence in the record indicates that the costs of compliance are not overly burdensome to industry. Having determined that the benefits of the proposed standard are likely to be appreciable, OSHA is not obligated to carry out further exercises toward more precise calculations of benefit which would not significantly clarify the ultimate decision. Previous attempts to quantify benefits as an aid to decision making in setting health standards have not proved fruitful (41 FR 46742).

TABLE 1.—*Estimates of costs of engineering controls for the textile industry*[1]

	Yarn preparation			Yarn processing		Total textile costs		
	Hocutt-Thomas[2]	RTI I[3]	RTI II[4]	Hocutt-Thomas[5]	RTI[6]	Hocutt-Thomas	RTI I	RTI II
Capital costs of equipment	467.3	978.8	685.2	75.7	7.7	543.0	986.5	692.9
Annual:								
Maintenance	7.6	10.1	7.0	.9	.1	8.5	10.2	7.1
Energy	40.8	67.9	47.5	8.2	.6	49.0	68.5	48.1
Equipment, annualized[7]	92.8	194.4	136.1	15.0	1.5	107.8	196.0	137.6
Total	141.2	272.4	190.6	24.1	2.2	165.3	274.7	192.8

[1] In millions of dollars.
[2] Assumes achievement of 0.2 mg/m³ (VE) for opening through roving, 0.5 mg/m³ (VE) for spinning-warping. In 1977 prices. Does not assume compliance with current cotton dust standard, but allows for $44.3 million in controls already installed.
[3] Assumes achievement of 0.2 mg/m³ (VE) for opening through spinning, compliance with current standard but without allowance for other installed controls, and controls installed on all production equipment, regardless of fiber processed. In 1974 prices.
[4] Adjusts RTI-I estimate by 30 pct reduction to eliminate controls on equipment to process only synthetics.
[5] Assumes achievement of 1.0 mg/m³ (VE) for yarn processing. In 1977 prices. Does not assume compliance with current standard.
[6] Assumes achievement of 0.5 mg/m³ (VE) for yarn processing, compliance with current standard but without allowance for any other installed controls. In 1974 prices.
[7] Capital costs annualized by factor of 0.19864 to reflect 9-yr depreciation period, 10 pct rate and allowances for equipment taxes and other costs. RTI estimates, initially estimated on the basis of a factor of 0.16075 to reflect an assumption of a 14-yr depreciation period, have been recalculated with the 0.19864 factor.

Sources: Ex. 60, Hocutt statement, for engineering control costs; Ex. 62, Thomas statement, for costs of temperature, humidity controls associated with Hocutt equipment costs; IIS, pp. I-15, V-17, V-29.

TABLE 2.—*Estimates of total compliance costs for the textile industry*[1]

	Hocutt-Thomas[2]	RTI I[3]	RTI II[4]
Capital costs:			
Engineering controls	543.0	[illegible]	[illegible]
Other provisions[5]	7.0	7.0	7.0
Total	550.0	[illegible]	[illegible]
Annualized costs:			
Capital, total	109.2	197.3	139.0
Operating, maintenance, and engineering controls	[illegible]	10.1	7.0
Other provisions[5]	4.3	4.3	4.3
Energy	49.0	[illegible]	47.5
Total	171.0	[illegible]	197.8

[1] See Table 1, note (1).
[2] See Table 1, notes (2), (5)
[3] See Table 1, notes (3), (6).
[4] See Table 1, note (4).
[5] Includes costs for medical, monitoring and other provisions as estimated by RTI.

Sources: Table 1, supra, and IIS, pp. I-15, V-17, V-29.

TABLE 3. ESTIMATED COSTS OF COMPLIANCE BY INDUSTRY SECTOR, IN MILLIONS OF DOLLARS

	Capital	Total annualized
Textiles [1]	550.0	171.0
Waste processing [2]	31.5	[illegible]
Seed processing [3]	75.0	[illegible]
Warehousing [4]		1.5
Total	[illegible]	[illegible]

[1] See notes on assumptions in Table 1, supra.
[2] The sum of estimates for waste recyclers and garnetting in Ex. 99e.
[3] Estimates from Ex. 93i.
[4] Estimates of Ex. 95i adjusted to exclude capital costs because of .5 μg/m³ permissible exposure limit of final regulation and to reduce monitoring and other costs in accordance with final provisions.

Sources: Table 2, supra, and Ex. 93i, 95i and 99e.

I. SUMMARY AND EXPLANATION OF THE STANDARD

The following sections discuss the individual requirements of the standard. Each section includes an analysis of the record evidence and the policy considerations underlying the decisions adopted pertaining to specific provisions of the standard. Based on consideration of all the evidence in the record, the final standard sets different limits of exposure to the lint-free respirable fraction of cotton dust for different segments of the cotton industry. To the extent appropriate, the requirements in this standard are similar to requirements in other OSHA health standards and reflect OSHA's regulatory policy for protection of the health of workers.

CONTINUATION OF STANDARD UNDER 1910.1000 TABLE Z-1

During the time period provided for instituting engineering controls to comply with the permissible exposure limit promulgated in this rulemaking, the current standard for cotton dust contained in 29 CFR 1910.1000 will continue in effect for yarn manufacturing. The current standard, which includes a requirement to implement engineering controls whenever feasible, was adopted in 1971 under section 6(a) of the Occupational Safety and Health Act. Since that time, employers have been under an obligation to comply with the 1.0 μg/m³ level for "cotton dust (raw)" provided under the standard. Although the current standard contains an exposure limit for total dust, whereas the new standard establishes a limit for respirable dust, efforts to comply with the standard importantly contribute to the employer's ability to comply with the new standard. The proposal envisioned that the new standard would generally build upon the protection provided under the current standard and would provide employees with greater protection consistent with new data concerning cotton dust exposure. No lessening of protection or hiatus of coverage was intended as a result of the proposal and promulgation of a new standard.

For employers who have complied with the current standard, compliance with the new standard will involve development of a compliance program to reduce exposures to the new 200 μg/m³ level and implementation of those new engineering controls over the time period provided. For employers, however, we have not yet complied with the current standard through engineering controls, the promulgation of the new standard is not intended to terminate the obligations to protect employees under the current standard. OSHA does not intend the 4-year compliance period under the new standard to reward employers who have not met their burdens under the current standard. By continuing to enforce the current standard until the employer complies with the new standard, OSHA will ensure that all yarn workers are accorded the protection provided by the current standard, while their employers work toward compliance with the new standard.

The requirements that employers who have not yet satisfied the current standard comply with as well as develop a compliance plan to meet the new standard are neither inconsistent nor inequitable. There is evidence that installation of engineering controls will be required to meet the current stand-

ard, and that these controls will be instrumental in bringing the employer into compliance with the new 200 μg/m³ level. (Ex. 16, pp. 19-21; Ex. 6, #109). Abatement under the current standard will involve implementation of controls which will help the employer reach the new standard. Further, it must be noted that employers have been under an obligation to comply with the current standard since 1971. Good faith efforts to comply with the 1 mg/m³ standard, where made have generally been successful in significantly reducing exposure to total dust as well as to respirable dust.

The current standard, however, will not continue in effect in weaving or in the non-textile segment of the industry after the new cotton dust standard becomes effective. As to non-textiles, case law developed from efforts to enforce the current standard has generally been adverse. OSHA has concluded therefore, that the continued application of the current standard to these employers would serve no useful purpose.

In the case of weaving, OSHA has concluded that enforcement of the current standard would impose a greater burden on the employer than meeting the provisions of the new standard. Evidence presented in the rulemaking demonstrated the introduced of considerable amount of biologically inert sizing materials during the slashing and weaving operations. On the basis of dose-response (Ex. 6, #51) and other data (Ex. 59, 59a; Ex. 108; Tr. 447), OSHA concluded that a higher exposure limit could be permitted in weaving without sacrificing worker protection. As a result, it does not appear that enforcement of the current more stringent level in weaving is appropriate while compliance with the new standard is being achieved.

A. *Scope and application.* This standard applies to all industries with exposure to cotton dust, with the exception, as noted below, of the maritime and agriculture industries. Thus, the standard applies to both textile and non-textile industries including yarn manufacturing, slashing and weaving, knitting, cotton seed mills, waste processing, classing and warehousing. This standard applies to mills processing cotton and synthetic blends as well as pure cotton, but does not apply to mills processing wholly synthetics.

The standard does not apply to dust generated solely from the handling of woven and knitted materials, such as dust generated during the manufacturing of garments from finished textile fabrics. Nor does the standard apply to processing of washed cotton.

The standard, as the proposal, does not cover harvesting because, as stated in the proposal, "it is a distinctively farming operation and presents different exposure environments and possibilities of control" (41 FR 56503). Cotton ginning is covered by a separate standard (29 CFR 1910.1046). This standard does not apply to agricultural operations.

The standard does not apply to the handling of cotton in the maritime industry. The weight of the evidence in the record shows the working conditions peculiar to the maritime environment render application of the cotton dust standard unnecessary. While some of the mitigating factors considered by OSHA in exempting the maritime handling of cotton overlap conditions sometimes found in other non-exempt industries it is the sum of the variables and their particular interaction which has led OSHA to except the maritime operation from the scope of this standard.

Testimony in the record supports the finding that maritime workers loading cargo on ships, are exposed to cotton dust for only brief periods. In Galveston, Texas, a cotton port, workers handle cotton bales for an average of 122 hours per year. Since Galveston is a major port for cotton shipments, the incidental cotton dust exposure in Galveston would appear to be of greater duration than that encountered in other U.S. ports. This limited duration of exposure makes it unlikely that cotton dust exposure is significant for any appreciable number of the workers handling water borne shipments of cotton.

Aside from the limited duration of exposure, the nature of the shipping operation mitigates the amounts of exposure for the typical cotton bale handler. Initially, cotton for shipment is pre-packaged into high density bales and covered with bagging on three-fourths of its area. The cargo men only handle the cotton when transferring the bales from warehouse to hold. Work in the enclosed ships' holds is rotated with work in the open air which is done with automatic equipment such as lifts and winches. In West Coast ports, the cotton is fully containerized and there is no worker exposure.

The West Gulf Maritime Association testified that it was unlikely engineering controls could be installed because of the structure of the industry. The maritime associations are merely labor brokers who rarely own the ships or barges. Ship owners, who handle cotton as a fraction of their cargo, are more likely to refuse cotton shipments than to install exhaust ventilation in their holds. The economic structure of the maritime industry would render apportioning of cost of engineering controls and even costs of other control programs problematical. These feasibility problems, however, are secondary to protection of the health of the workers. The primary evidence requiring exclusion of the maritime industry is the pattern of incidental exposure, the indications that levels of exposure, even under the worst possible conditions, are minimal on a time-weighted exposure basis, and the lack of any data showing that the level and extent of exposure presents a hazard to cargo loaders.

In the preamble to the proposed cotton dust standard, OSHA recognized that health problems similar to those observed in the textile industry do exist in non-textile industries which process cotton. Thus the Agency did not limit the scope of the proposed standard to the textile industry. Upon reviewing the entire rulemaking record, OSHA has concluded that the epidemiological evidence described below provides additional support to the decision to include all exposures to cotton dust within the scope of this final standard.

Dr. David Barman, a private physician, conducted a survey of employees in one California warehouse—compress facility. Neither the 14 workers registering respiratory complaints during pre-screening nor the 6 asymptomatic workers reported byssinosis on a self-administered questionnaire. However, pulmonary function testing revealed tht 5 of these 20 workers would have required periodic retesting according to the criteria established in the proposed standard. Furthermore, 12 of the 14 workers complaining of respiratory symptoms during the pre-screening worked around the compress which has been shown to be a major exposure point to cotton dust in warehouse operations.

In a 1976 study of English willowers, Chinn et al. reported 8 of 32 workers showing a significant (greater than 10%) drop in pulmonary function. Over half of the 60 workers studied expressed symptoms of chronic bronchitis although only 5% reported byssinosis on a questionnaire.

A NIOSH survey of a garnetting facility showed an 11% prevalance of byssinosis among 34 workers exposed to dust levels ranging from 3.6-10.9 μg/m³ (vertical elutriated) in the garnetting department and from 0.24-0.43 μg/m³ in the mattress-making areas. Twenty had symptoms consistent with chronic bronchitis. Moderate pulmonary function changes were reported in 6 workers. NIOSH cautioned that use of respirators on the day of the testing could have suppressed noticeable dust effects, thereby underestimating the prevalance of both objective and subjective symptoms.

In Australia, Barnes and Simpson found an averge post-shift fall in FEV_1 of 0.12 liters (0.28 liters in dusty areas) among 26 garnetters. Preliminary results of Noweir's research in Egypt in-

dicated byssinosis prevalance on the order of 15% and FEV_1 decrements (greater than 10%) in 10% of cotton waste workers exposed to dust levels as low as 1.0 $\mu g/m^3$ respirable dust.

An Australian study of one cottonseed delinting plant demonstrated significant pulmonary function changes in more than half of the workers. Similarly, Noweir et al. noted that 30 percent of the work force exposed to cotton dust in two Egyptian cottonseed oil mills complained of byssinotic symptoms.

Although these studies of non-textile industries do not provide precise dose-response data, this data clearly establishes that exposure to cotton dust in these industries, regardless of the stage of processing in which the dust is generated, results in byssinosis and other respiratory diseases qualitatively indistinguishable from those arising in the cotton textile industry. OSHA has concluded that the record conclusively establishes that exposure to cotton dusts of the composition regulated by this standard poses a health hazard to employees in non-textile industries.

The standard does not apply to the handling or processing of cotton which has been "thoroughly washed in hot water." In exempting washed cotton, OSHA recognizes the effectiveness of the washing process in significantly reducing or eliminating the biological effects of cotton dust. Testimony by Dr. Merchant indicated that the reduced biological effects observed in washed cotton may be the result of reduced dust levels or because the active agents in the dust are eliminated by washing. The resulting dust levels upon washing were below 100 $\mu g/m^3$ so it is impossible to determine the absolute basis for the reduced activity (Tr. 1035). Exemption of washed cotton is consistent with the recommendation of NIOSH and other parties that washed cotton be considered processed cotton.

The washing process can be as simple as the water washing of baled cotton with a wetting agent described by Merchant, or as elaborate as the bleaching and purifying processes commonly practiced in the health products industry (Tr. 1016, Ex. 96). Washed cotton, however, does not include cotton which is steamed or autoclaved. While both steaming and autoclaving cotton prior to manufacturing have been used as means of reducing the health hazard from cotton dust and have resulted, in certain processes, in some reductions in dust levels and improvement in pulmonary function there is no evidence that either method is as effective as washing in controlling the problem. In fact, a study in a Burlington mill, although noting an improvement in FEV, decrement in preparation during which cotton fibers are steamed, established that dust levels and pulmonary effects increased in post-preparation areas, due possibly to adherence of the dust to cotton fibers because of the steaming. Although Imbus and Suh suggested that steaming might serve as an adjunct to exhaust ventilation in dust control, it does not appear that steaming alone is as effective as washing. Nor is there evidence in the record that washing with solvents is as effective as water. Therefore, in the absence of more persuasive evidence on the effectiveness of steaming or washing with solvents in reducing employee exposure to cotton dust, only cotton washed in water is exempted.

This final standard establishes mandatory requirements for the control of employee exposure to cotton dust. These requirements are reasonable and appropriate for achieving the health protection considered necessary and are based on the entire record of this proceeding, including the extensive evidence concerning the types of controls and procedures currently utilized by many covered employers. OSHA recognizes, however, that changing technology, new equipment and procedures, as well as experience gained by industry in the implementation of this standard may lead to the development of alternative means of protecting employees which are as effective as, or indeed more effective than, those set out in this standard.

It is not OSHA's intention by promulgating this standard to discourage or inhibit this kind of innovative development. On the contrary, to the extent that new and more effective methods will make the goal of employees health more readily achievable, adoption of these methods will better effectuate the purposes of the Act. It is for this reason, in part, that section 6(b)(5) of the Act expresses a preference for the issuance of performance standards to the extent practicable.

We note, therefore (and have included a reference in the standard), the provisions of section 6(d) of the Act which provide for the grant of variances to employers who can show that they have developed alternative means of providing employment and places of employment which are as safe and healthful as those required by the standard. As implemented by the procedural regulations in Part 1905 of this Title, the variance provisions of the Act permit the flexibility which contributes to efficient compliance with the standard. To aid in the expeditious processing of variance applications, the procedures allow, where appropriate, for the grant of interim orders pending a decision on the merits of the variance as well as for the consideration of variances applicable to groups of employers. OSHA encourages interested employers to utilize the variance provisions of the Act where equally safe and healthful protective means are available.

B. *Definitions.* The final standard contains eight definitions some of which are changed from the proposal. The definition of cotton dust is discussed in detail in section IV, Permissible Exposure Limit (general). The definition of washed cotton has been expanded to make it clear that the exemption does not apply to washing with solvents. A definition of yarn manufacturing has been added to make clear what textile processes are subject to the 200 $\mu g/m^3$ permissible exposure level. A definition of lint free respirable cotton dust has been added to make clear what fraction of cotton dust is sampled, since the permissible exposure limits are now expressed in terms of lint free particles.

C. *Permissible exposure limits.* The standard prescribes three separate permissible exposure limits. The permissible exposure limit for yarn manufacturing processes in the textile industry is 200 $\mu g/m^3$ of lint-free respirable cotton dust averaged over an eight-hour work shift. The permissible exposure limit in the textile processes known as slashing and weaving is 750 $\mu g/m^3$ of lint-free respirable cotton dust averaged over an eight-hour work shift. In all other industries where employees are exposed to cotton dust, including knitting, the permissible exposure limit is 500 $\mu g/m^3$ of lint-free respirable cotton dust averaged over an eight-hour work shift. The evidence and rationale supporting these environmental levels are discussed in detail in the preamble under section IV, Permissible Exposure Levels.

D. *Exposure Monitoring and Measurements.* The final standard, like the proposal, requires that the employer monitor employee exposure to cotton dust. OSHA discussed methods of exposure measurement in detail in its proposal and in particular, significant attention was devoted to sampling devices and personal versus area sampling. In enforcing the then existing regulation (29 CFR 1910.1000) OSHA was required to measure total airborne particulates. In that context OSHA believes that the personal sampler, a measuring device worn by an employee while at work, most closely reflects the total airborne particulates in the breathing zone. The preamble to the Secretary's proposed cotton dust standard recognizes the advantage of the personal sampler:

"There are definite advantages (sic) in relating a dust concentrator measurement to a particular employee's exposure. Thus, wherever possible, OSHA has considered the use of personal sampling devices that can be worn by an employee through the working day to be superior to area samplers, even though OSHA is using personal sampler

consisting of a portable pump to which an open face filter is attached by means of flexible tubing. The filter is then attached to the employee's lapel or collar . . ." (41 FR 56505, December 28, 1976.)

In addition, personal samplers constitute a basic sampling methodology for measuring employee exposure to many toxic substances, such as lead, asbestos, coke oven emissions, etc. In sum, personal sampling is recognized by OSHA and the scientific community as an established method of monitoring employee exposure to airborne toxic substances.

Second, the currently enforceable cotton dust standard, which establishes a permissible exposure limit for "cotton dust raw" reflects the correlation between exposure to cotton dust in general and adverse health effects. However, OSHA has determined there is a more consistent correlation between lint-free respirable particulates and adverse health consequences. Accordingly, under the proposal OSHA has examined the appropriateness of a permissible exposure limit based upon a size-selective dust measurement, i.e., lint-free respirable particulates. The studies which establish this correlation are based upon area dust sampling using the vertical elutriator. However, by considering the use of different sampling techniques and devices, which are the products of developing research, the Secretary is not repudiating the previous cotton dust standard or the techniques for determining compliance therewith. The required sample remains a lint-free respirable dust sample, but the sampling device to be used can be either the vertical elutriator (VE) or a method of equivalent accuracy and precision. This represents a major change from the proposal, as explained more fully below. The procedures specified for collection and analysis of environmental samples when using the vertical elutriator, as provided in Appendix A, are now advisory in nature, which is intended to allow for flexibility.

Medical and environmental evidence presented in the preamble to the proposed cotton dust standard demonstrating the preferability of a respirable dust sampling to depict employee exposure, was not disputed. Most investigators (Ex. 41, 51, 66; Tr. 530) agreed that the correlation existing between a respirable dust sample and observed health effects mandates the use of a sampling device which enables measurement of respirable dust particles. In fact, permissible exposure limits first formulated in the proposal were based on data obtained through the use of the vertical elutriator.

One major change adopted required redefinition of the cotton dust fraction to be measured, from a vertical elutriated sample to a lint free-respirable dust sample. The term "vertical elutriated" refers to the method of precollection or separation of the respirable and non-respirable fraction, and not the type of dust sample, whereas respirable refers to particles which are capable of deposition in the respiratory tract.

OSHA recognizes the many problems associated with the use of the vertical elutriator. (42 FR 56505). However, representatives from Burlington Industries, ACTWU (Tr. 996), NIOSH (Tr. 996) and the North Carolina Department of Labor agree with OSHA that the vertical elutriator is currently the best sampling device available for separating particles with aerodynamic diameters above 15 microns from the respirable portion of cotton dust. This consensus was based on an evaluation of data collected by the vertical elutriator which demonstrated conformity with precision and accuracy requirements prescribed in the final standard (Tr. 1052).

In requiring the vertical elutriator as the approved sampling device for cotton dust, OSHA is not eliminating the use of other sampling devices where equivalency can be demonstrated. OSHA has provided in the standard that devices equivalent to the vertical elutriator may be used for cotton dust.

While equivalency criteria must be established independently for each proposed device, minimum equivalency must be determined either theoretically or experimentally by demonstrating that the device uses standard statistical principles to classify aerosols aerodynamically according to size as does the vertical elutriator (effective cutoff of 15 microns) and side-by-side equivalency in field situations with the standard vertical elutriator must be demonstrated to be within an accuracy and precision of plus or minus 25 percent or 95 percent of the samples over the range of 0.5 to 2 times the permissible exposure limit.

One device for which equivalency was claimed during the hearings was the GCA-RDM 101, which is one type of sampling device. Pedro Lilienfield of GCA Corporation presented evidence that the portable direct readout dust monitor, model RDM-101 is equivalent to gravimetric techniques for measuring respirable dust concentrations.

NIOSH representatives argued against acceptance of the GCA RDM 101 because equivalency had not been adequately demonstrated. Above 700 ug/m^3 there is deviation from equivalency for the RDM 101 (TR. 2032). Mr. Lilienfild admitted on cross examination that the data collected by the GCA on levels above 700 ug/m^3 "is somewhat insufficient" (Tr. 3653).

Also, Mr. Lilienfild admitted that equivalency had not been demonstrated for all processes beyond opening, picking and carding in the textile mill nor in the nontextile industry (TR. 3656). Consequently, the utility of the GCA RDM 101 monitoring device in situations where side-by-side equivalency has not been demonstrated is questionable.

While there are definite advantages in using a sampling device similar to the GCA monitor, the rulemaking record raises significant questions which must be addressed before OSHA will accept that device as equivalent to the vertical elutriator. OSHA re-emphasizes that only devices which positively demonstrate equivalency with the standard vertical elutriator (equivalency as described above) will be accepted as alternative sampling devices. The burden of proving equivalency of alternative methods rests with the employer utilizing an alternative device. While OSHA insists on the demonstration of equivalency for any proposed alternative sampling devices, OSHA continues to encourage the development of alternatives, especially size selective personal samplers.

The sampling procedures proposed by OSHA in Appendix A received extensive criticism during the hearings. Representatives from the North Carolina Department of Labor and Mr. Frank Mackison from NIOSH testified that Appendix A should be changed from a required strategy to a recommended method. This would assure flexibility and enable industrial hygienists to exercise professional judgment in establishing optional sampling protocols (Tr. 4152). Dr. Neefus supported this position and agreed that the workplace must be properly assessed before appropriate sampling protocol can be determined.

On the other hand, ACTWU urged that Appendix A be mandatory as initially proposed by OSHA (PH #36), because or its value to non-professionals. Dr. Y.Y. Hammad of Tulane University also agreed that Appendix A should be required because "requiring this particular protocol forces consistency in measurements between different people who are performing the measurements".

OSHA agrees that Appendix A may not be flexible enough to cover all situations in which samples need to be collected. For example, Neefus argued that greater flexibility was required with respect to duration, sequence, location and number of samplers (2000-2003). Accordingly, Appendix A is only advisory in nature.

The final standard requires that monitoring of all employees exposed to cotton dust must be completed as soon as possible but not later than 12 months of the effective data of the standard. The North Carolina Department of Labor testified that one year was necessary to implement a sampling program due to current produc-

tion schedules and delivery dates. (Tr. 4154). OSHA believes that monitoring must be completed at the earliest date in order that employers can take appropriate steps to protect the health of their workers. Taking into consideration production rates of monitoring equipment and anticipated delivery dates, OSHA believes that the North Carolina recommendation of one year allows sufficient time for completion of the monitoring.

The standard also requires remeasurement of employee exposure at least every 6 months. This requirement was included in the proposed standard to ensure that the employees exposure measurement represents current exposure conditions. Periodic monitoring enables the employer to take appropriate measures for the protection of his employees. As already pointed out, adverse health effects from cotton dust exposure may occur at levels below the permissible exposure limit. Therefore, regardless of the airborne concentration of cotton dust, exposure measurements when coupled with the required medical data will enable both the employer and OSHA to evaluate the effectiveness of the permissible exposure level in the reduction of the prevalence of byssinosis.

The standard also requires that whenever there has been a production, process, or control change which may result in new or additional exposures to cotton dust, or whenever the employer has any other reason to suspect an increase in employee exposure, the employer shall repeat the required monitoring for those employees affected by the change or increase. Neefus agreed that it is basically a good industrial hygiene practice to sample an area after major equipment, ventilation, or process control changes. However, he pointed out that minor process changes takes place daily in many textile mills, such as changes in blends, cotton mix, counts and yarn, or temporary slow downs which, under strict interpretation of the proposal, would require daily sampling (Tr. 2003). To resolve this problem, Neefus recommended that there be re-determination of exposure only when a "major change" occurs and that a "major change" be defined as a blend ratio changing from 65-35%, 50-50%, or an engineering or humidification change (Tr. 2016, 2017).

The record demonstrates the difficulties in attempting to distinguish between major and minor changes. Therefore, the final standard does not incorporate Neefus' suggestion. However, OSHA believes that, with the development of a sampling protocol specifically for each operation, persons responsible for taking samples will be able to determine which operational changes will result in elevated dust levels, requiring additional monitoring.

The standard requires employers to collect at least one sample during each shift for each work area: This differs from the proposal insofar as the sample is now for each work area where before it was for each job classification. All of these requirements are intended to ensure that the monitoring is truly representative of the employee's exposure over an eight hour period. Since exposure conditions vary throughout the day, at least one sample is to be taken during each shift in order to ensure that exposure measurements represent exposure of employees on all shifts. Full-shift samples give more accurate indication of an employee's average exposure during a work shift than would sampling for less than full shift. Short term samples would tend to be affected by the variability of cotton dust emissions. Full-shift samples tend to average out these variations. It should be emphasized that Appendix A specifies that six-hour samples be collected and not 8-hour samples. this is partly due to the time required to set-up sampling equipment, calibrate, and finally to remove sampling equipment, or in other words sufficient time must be allowed in any sampling strategy for such mechanical functions to be performed. In addition, a sufficient number of samples and locations in each work area must be sampled to ensure that the monitoring is truly representative of an employee's exposure.

(E) *Methods of Compliance.* This final standard requires employers to institute engineering and work practice controls, and respiratory protection, to reduce employee exposure to cotton dust to or below the permissible exposure limits according to a specific schedule. This requirement is in accord with OSHA's policy that feasible engineering and work practice controls must be used as the primary methods of reducing employee exposure. This policy is based upon the view that the most effective means of controlling employee exposures is to reduce emissions of toxic substances at their source through the use of mechanical means combined with work practices rather than through reliance on the variability of human behavior so critical to the successful use of respirators.

This standard also provides that, in situations where feasible engineering controls and work practices are insufficient to reduce exposure to the permissible exposure limits, the controls must nonetheless be used to reduce exposures to the lowest achievable level and then be supplemented by the use of respiratory protection. While respirators are not the preferred means of controlling employee exposure, respiratory protection must be utilized to reduce employee exposure during the period required for installation of engineering controls, where engineering controls may be inappropriate, such as during some maintenance operations, or in those cases when both engineering controls and work practices do not succeed in reducing exposures below the permissible exposure limit.

Some hearing participants recommended a control strategy involving principal reliance on respiratory protection, to reduce the cost of compliance. However, respirators have many disadvantages which preclude primary reliance or co-reliance on respiratory protection on an equal basis with engineering and work practice controls. The many difficulties with respiratory protection were enumerated at the hearing by respirator expert Bruce Held (Tr. 483): because of difficulties in face fit, it is difficult to know whether the respirator actually provides adequate protection; respirators, by interferring with vision, hearing, and mobility, can cause safety problems; some employees cannot wear respirators because of breathing difficulties. Finally, it is not appropriate to place the burden of compliance principally on the employee, as would be the case if respiratory protection were the principal means of reducing employee exposure. Therefore, OSHA retains in the standard the policy of principal reliance on engineering controls and work practices, except in circumstances where there is no feasible alternative to reliance on respiratory protection.

Even in situations in which engineering controls will not succeed in reducing exposure levels below the permissible exposure limit, it is still appropriate to require all feasible engineering controls to be installed, even though they would have to be supplemented by the use of respiratory protection. The engineering controls, by reducing the exposure, will minimize the potential for over exposure resulting from poorly fitting respirators, and may reduce the number of employees who need to wear respirators.

The assessment of the feasibility of engineering controls in reducing exposure to cotton dust is discussed earlier in this preamble. Since it has been established that the standard is generally feasible, the burden of proving infeasibility in any particular case clearly rests on the employer. The employer is in the best position to gather evidence on feasibility in his workplace. The employer is most familiar with production processes and the engineering modifications which are applicable. Further, it is OSHA's policy that employers be required to take steps to investigate the feasibility of controls and install them as necessary.

The Proposed Cotton Dust Standard provided for the phasing-in of control technology over a period of seven

years from the effective date of the standard. This phase-in program was based upon RTI's assessment of problems with the implementation of engineering controls to achieve a 200 $\mu g/m^3$ level in all industries with cotton dust exposure. The phase-in program involved a three tiered approach to compliance in which employers were required to achieve 500 $\mu g/m^3$ immediately, 350 $\mu g/m^3$ in four years, and finally 200 $\mu g/m^3$ in seven years. This final standard differs from the proposal in several important respects.

The record of this proceeding demonstrates that the permissible exposure limits established are feasible, and that compliance with these limits can be achieved in a much shorter time than proposed. The final standard is based on voluminous evidence offered by numerous parties during the hearing. That evidence shows significant advancement in dust control especially by the major yarn manufacturing companies, which include efforts to install new production equipment which is both cleaner and more adaptable to ventilation equipment. As described below there was conflicting evidence regarding the time period required for implementation of engineering controls. Although controls have been instituted in some parts of the industry compliance has not been achieved in the vast majority of affected industries, and therefore any determination of the time required for complete implementation of controls throughout industry must be seen as a best estimate rather than established fact. Based upon these considerations and the record evidence OSHA has determined that compliance can be achieved throughout industry in four years from the effective date of the standard.

The Research Triangle Institute (RTI) suggested, based on conversations with control equipment vendors, that compliance with the 200 $\mu g/m^3$ limit in yarn processing could take "perhaps 8 years or more," and compliance by other sectors might require 2-3 years more than yarn producers. The primary determinant was the ability of the control industry to design, produce, and install equipment that will reliably produce the required levels.

RTI's assessment was based on the most laggard mills rather than the typical. Most significant, however, was OSHA's modification of the exposure limits in weaving and in non-textiles, which is likely to replace the need for expensive and difficult dust control requirements with clearly achievable or already achieved measures.

For example, H. Hocutt estimated that 72 percent of the weaving operations are currently in compliance with 750 $\mu g/m^3$ (Tr. 2419). Similarly compliance with the 500 $\mu g/m^3$ permissible exposure limit for non-textiles should be accomplished with less difficulty than anticipated in the proposal; in fact much of the industry is already in compliance with this level.

The North Carolina Department of Labor testified that five years would be required for implementation of controls (Tr. 4156) and there was some industry testimony which indicated at least three years was to be anticipated for controls. In answer to the following inquiry addressed by NIOSH to extramural consultants in 1972, Dr. Imbus responded:

> *"Question:* If you feel that they (the textile industry) can not meet these requirements at the present time what length of time would you allow to meet these requirements?
>
> *"Answer:* I believe it would be necessary to allow at least three years to meet a dust standard of .2 milligrams per cubic meter. I believe medical controls could be achieved in most instances with one year."

The record does indicate that installation of dust control systems may occur in significantly shorter times than already described.

Dr. R. Soule testified:

> "it is recognized that many cotton processing operations have little or no provisions for local exhaust or general ventilation. The time period from design of a system to implementation in the plant in such situations easily could extend to six months or more. In other plants, the basic components of controls systems are present, but in need of repair and general upgrading. In these situations significant improvement in dust control capability could be achieved in a matter of four to six weeks."

Installation of dust control systems in less than six months was described in the NIOSH document "Cotton Dust Controls in Yarn Manufacturing." This publication outlined in detail the efforts at dust control by Pneumafil Corporation during the early seventies and documents the fact that controls could be installed in six months or less (Ex. Ref 109).

OSHA does not believe however that implementation of engineering controls is attainable in these brief periods throughout industry. It is obvious that design, manufacture and installation of controls within a short period throughout industry would place an unrealistic burden on the manufacturers of control technology especially when one considers the large number of textile plants affected by the standard.

Based on this extensive testimony OSHA has concluded that implementation of engineering controls both in brief periods of less than a year or extended periods of 7 to 8 years are unrealistic for the reasons cited. A period of 3 to 4 years for implementation throughout industry is eminently reasonable and achievable. OSHA will therefore require complete implementation of engineering controls no later than 4 years from the effective date of the standard.

OSHA recognizes that some time will be required for implementation of engineering controls. First, each employer must monitor employee exposure and determine the level of employee exposure. This monitoring must be completed no later than March 4, 1979. Using this monitoring data, the employer must take steps to develop a written compliance program. These steps include identifying the source of emissions for which controls must then be designed, purchased, manufactured, delivered and installed. It is contemplated that to develop this program most employers will need to rely on professional experts. The standard requires that this written compliance program be completed no later than 12 months after the standard's effective date, (i.e., by September 4, 1979).

Having completed this compliance plan, employers are then given a period of 36 months (until September 4, 1982) in which to complete installation of engineering and work practice controls which reduce employee exposure to or below the P.E.L. OSHA finds that such a period of time for completion of engineering controls will be needed by a large number of employers within the covered industries. Accordingly, taking into account the requirements of the statute that OSHA consider "the feasibility of standard", OSHA has determined that employers are required to complete implementation of engineering and work practice controls by September 4, 1982. As discussed below, employers who have developed an adequate compliance plan and are implementing the plan on schedule will not be subject to citation during this period for failure to have completed installation of engineering controls.

Initially, all employers will be required, by October 4, 1978, to provide any dust respirator, including single use respirators, to every employee, except where the employer can demonstrate that employee exposure is below the permissible exposure level.

As explained in the respirator section *supra*, as soon as an employer completes monitoring, but no later than March 4, 1979, he is required to provide the respirator which is appropriate for the measured levels, in accordance with the respirator selection table requirement.

This final standard specifies the contents of the compliance plan. OSHA views the written compliance plan as an essential part of the compliance program since it will encourage employers to actually achieve the controls and also provide the necessary documentation to OSHA, employers and employees of the compliance methods chosen, the extent to which

controls have been instituted and plans to institute further controls to achieve safe and healthful workplaces.

The standard requires that the employer establish the written plan no later than September 4, 1979. This plan must set forth a schedule whereby the employer will reduce exposures, solely by means of engineering and work practices controls, to or below the permissible exposure limit no later than September 4, 1982.

Upon examining the employer's compliance plan, the Secretary will determine whether the schedule for development and implementation of engineering and work practice controls is designed to and will achieve compliance with the P.E.L., by these means, by September 4, 1982. OSHA will take enforcement action in cases where the compliance program does not project the implementation of these controls by that date, or where it appears that the schedule for implementation is extended such as to render completion by September 4, 1982 unlikely. In addition, the employer who has developed an adequate plan for reducing employee exposure below the P.E.L. but does not meet the scheduled implementation dates, in the plan, will be subject to citation.

These written plans must be furnished upon request for examination and copying to representatives of the Assistant Secretary and the Director and to affected employees and their designated representatives. They must be reviewed and updated periodically to reflect the current status of exposure control. OSHA views the requirement for written plans as an essential part of the compliance program since it will form the basis for determining the employer's ability to achieve the controls and provide the necessary documentation to OSHA of the compliance methods chosen, the extent to which controls have been instituted, and of the plans to institute further controls.

F. *Respiratory Protection.* The standard requires that respirators be used only in limited circumstances: during the time necessary to complete initial monitoring any dust approved respirator including single use respirators shall be required except where the employer can demonstrate through previous monitoring results that the permissible exposure limit is not exceeded: during the time period necessary to install or implement feasible engineering and work practice controls, in operations where engineering control are not feasible such as some maintenance operations, in work operations in which controls are not feasible or are not yet sufficient to reduce exposure to the permissible exposure limit, and whenever an employee requests a respirator. This last requirement is to provided protection for those employees who are sensitive to cotton dust exposure even below the P.E.L.

OSHA's decision to require single use respirators during the period of time required for completion of initial monitoring is based on the knowledge that given current production and delivery rates for monitoring equipment initial monitoring may not be completed throughout industry for six months. The agency has concluded that employees should be protected from exposure to cotton dust throughout this period rather than waiting for the results of initial monitoring. In those situations where the employer has already performed exposure monitoring respirators will only be required for employees exposed to cotton dust in excess of the permissible exposure limit. Since in most cases the employer will not have knowledge of the airborne concentration of cotton dust use of the respirator table will not be relevant and therefore OSHA will require use of any approved dust respirator. Where the employer has knowledge of the airborne levels then he must use the respirator table to determine which respirator is appropriate.

Where the permissible exposure limit is exceeded and engineering controls and work practices do not succeed in reducing exposure below the permissible exposure limit, it becomes necessary to utilize respirators to give health protection to employees. Under these circumstances, therefore, the employers must provide the employee with the appropriate respirator and assure that the employee uses the respirator.

The standard also requires that respirators be worn during "blow downs". The need to protect employees from the elevated exposures encountered during the cleaning of equipment and surfaces with compressed air is discussed in detail in the section on work-practices.

The standard further requires that the employer select respirators from among those approved by NIOSH under 30 CFR Part 11. The standard includes a selection table for the employer to use which will provide for the selection of respirators which will afford the employee the proper degree of protection. This table is based on protection factors which are primarily a measure of face fit and OSHA's standardized decision logic for respirator selection (Tr. 485). The respirator table in the final standard reflects changes from Table I of the cotton dust proposal (41 FR 56516–7) which are based on an analysis of the record evidence.

There are two major changes in respirators from the proposal to the final standard. Other proposed requirements for respirators were substantially uncontroverted. One major change from the proposal is the inclusion of the single-use respirator in the selection table. Single-use respirators were excluded from the selection table section of the proposal because they could not achieve a protection factor of 10. The protection factor of single-use respirators has been disputed. OSHA's decision to include single-use respirators was based on testimony by NIOSH that single-use respirators can achieve a protection factor of 5 and are approved by NIOSH for protection against pneumoconiosis and fibrosis producing dusts (Tr. 487; Tr. 4240; Ex. 38 Appendix 10).

OSHA is well aware of the problems associated with the use of a single-use respirator, and recognizes that there are no fit tests available for individual employees to determine proper fit. OSHA, however, agrees with respiratory experts that an employee should be able to achieve leakage of about 20% or less with careful fitting which a protection factor of 5 would allow (Tr. 487).

There are other considerations favoring use of the single-use respirators. Because they are light weight and create lesser breathing resistance and communication interference, single-use respirators have received wider acceptance among workers than have other respiratory devices. Retired and active workers have echoed this acceptance (Ex. 54a, p. 12; Ex. 82, p. 9–10), and the North Carolina Department of Labor (Ex. 108) recommended single-use respirators, characterizing them as "the most comfortable, economically feasible, and sanitary in many environments." Wearer acceptance and training are critical to the success of any respirator program. Given the compelling testimony describing wearer acceptance of the single use respirator OSHA has added a provision to this section which will require the employer to comply with an employees's preference for a single use respirator, whenever respirators are required by this section for concentrations not greater than 5X the applicable permissible exposure limit.

The second major change in the respirator selection table is the establishment of a protection factor of 100 for full facepieces under negative pressure instead of the factor of 50 in the proposal. Hearing participants presented studies conducted at the Energy Research and Development Administration facility at Rocky Flats and at Lawrence Livermore laboratory which showed that 100% of the employees could get a protection factor of at least 100 on at least one make of full facepiece (Tr. 486). After reviewing this data, OSHA has concluded that a protection factor of 100 for full facepiece respirators under negative pressure is appropriate.

To assure that employees receive the maximum protection from exposure to

cotton dust, OSHA has required the use of respirators which exhibit minimum facepiece leakage. For single-use respirators, for which no really objective test exists, employees are cautioned to report respirators which have obvious leakage. Usually, this leakage can be assumed when the employee feels large amounts of air penetrating the seal of the facepiece. For non-powered, particulate filter respirators, semi-quantitative fit tests were required annually in the proposal. Since there was no testimony describing the specifics of semi-quantitative fit test OSHA has reconsidered this requirement and does not require semi-quantitative fit tests in the final standard.

The standard also requires that employees wearing filter respirators be permitted to replace the respirator filter whenever they detect an increase in breathing resistance. When the filter becomes loaded, the movement of air through the filter becomes restricted forcing the employee to breathe harder to overcome this resistance. The wearing of a respirator becomes increasingly uncomfortable and discontinued use may result. To aid in minimizing the discomfort of wearing a respirator and to keep the respirator working efficiently, the employee must be allowed to change filters as the need arises.

The wearing of a respirator in a dusty environment can result in skin irritation, as the dust may accumulate around the facepiece seal. To prevent this irritation and to minimize the discomfort of respirator use, employees must be allowed to periodically wash their faces and respirator facepieces, in order to remove any accumulation of dust.

While it is known that worker resistance to wearing respirators can be great, much can also be done to eliminate this problem (Tr. 3042; 4180–1). The employee must be properly trained to wear the respirator, to know why the respirator is needed, and to understand the limitations of the respirator. An understanding of the hazard involved in necessary to enable employees to take steps necessary for their own protection.

The standard further requires that the employer institute a respiratory protection program in accordance with 29 CFR 1910.134. That standard contains basic requirements for proper selection, use, cleaning, and maintenance of respirators.

The standard requires the employer to provide respirators for protection from exposure to cotton dust "at no cost to the employee". OSHA has allocated the costs of respirators required for protection from exposure to the employer in order to effectuate the purposes of the Act. The employer will be in the best position to provide the correct type of equipment and keep it in repair. The employers' costs in providing respirators and protective equipment and clothing were considered in the economic assessment. This language in the standard makes explicit the position which has long been implicit in all OSHA health standard proceedings under section 6(b) of the Act.

The final standard contains a limited employee transfer option for those employees incapable of wearing any form of respirator. The final standard recognizes that engineering controls are the preferred method of controlling cotton dust hazards; that it will take up to four years for employers to implement engineering controls to reach the permissible exposure limit; and, to afford employee protection during this interim period, the final standard permits the use of respirators instead of engineering controls. In light of these provisions, OSHA anticipates that it will be necessary for many employers to place reliance upon respirators as a principal means of worker protection during much of this 4 year period.

Due to the high incidence of diminished pulmonary function among existing cotton dust workers, OSHA expects that some employees will be found to be incapable of wearing a single use or other form of negative pressure respirator. As a result, the medical surveillance provisions of the standard include a requirement that an examining physician determine an employee's ability to wear respirators. In situations where a negative pressure respirator cannot be worn, the examining physician must determine the employee's ability to wear a powered air purifying respirator (PAPR).

OSHA expects that in a limited set of circumstances, certain employees will be incapable of even wearing a PAPR. An employee under such circumstances, in the absence of some opportunity to transfer to a position where a respirator need not be worn, might very well be discharged, or otherwise sustain economic loss, due to his or her inability to wear a respirator. OSHA views such a result as exceedingly harsh. It is manifestly unfair that employees who are unable to wear respirators suffer loss of jobs or other economic detriment because their employers have not yet achieved compliance with the engineering control requirements of the standard, but are relying instead on the interim and less effective device of respirators. During the multi-year period prior to the full implementation of engineering controls, this risk of adverse economic impact on employees is a real one. Accordingly, we conclude that where the employer is relying upon respirators as the means of limiting worker exposure, his or her compliance obligation must include the obligation to assure that employees who are unable to wear respirators not suffer any economic detriment. More specifically, a provision is included in the final standard which offers employees incapable of wearing any form of respirator, including a PAPR, the option to transfer to another position which is available or later becomes available having a dust level at or below the PEL. In concert with this transfer option, the standards requires that employer assure that an employee who is transferred due to an inability to wear a respirator does not suffer loss of earnings or other employment rights or benefits as a result of the transfer. The goal of this provision is to minimize any adverse economic impact on the employee by virtue of the inability to wear a respirator. The "available position" aspect of the provision recognizes that a suitable position may not always be immediately available, but the standard contemplates that the employee be given the opportunity to transfer to an appropriate position if an when such a position arises.

It is OSHA's judgment that this restricted form of job transfer without loss of earnings or other employment rights or benefits should only have to be invoked in the most unusual of circumstances, but, the protection it affords should greatly increase the success of the standard's respiratory protection provisions. As noted elsewhere in the preamble, the broad questions of mandatory medical removal of cotton dust workers, and medical protection, are not addressed by this final cotton dust standard, but will be discussed in the forthcoming inorganic lead standard. It is appropriate to note that the limited transfer option contained in this final cotton dust standard is adopted solely in response to the special role of respiratory protection in this standard, and is not meant to reflect the agency's evolving perception of the overall problem of medical removal protection.

G. *Work practices.* The preamble to the proposed cotton dust standard states that "in most processes in which cotton dust is present, even exposures below the permissible exposure level may be harmful, as there is no safe level of exposure. Therefore, definite work practices and procedures must be instituted to control employee exposure" (41 FR 5606). Virtually no testimony was presented during the hearings to contradict this statement, and in fact, there was testimony to the effect that many textile employers have established work practices. While no direct evidence as to work practices in non-textile industries was submitted, neither was there any questioning of the need for and the feasibility of work practice controls in any of the non-textile operations.

The standard specifies the work practices which the employer must institute. For example, the standard requires the employer to inspect, clean, maintain and repair all engineering control equipment and ventilation systems, including power sources, ducts and filtration units of the equipment. It is generally accepted as good industrial hygiene practice to provide maintenance of control and ventilation equipment. Testimony presented during the hearings (Ex. 17, p. 4) indicated that significant improvements in reduction of cotton dust levels in the cotton industry could be achieved by simply maximizing the effectiveness of the existing control mechanisms. Maintenance of local exhaust hoods, duct work, dust colletion equipment and fans in optimum condition programs of total systems maintenance, and good work practices must be used or the most highly-sophisticated engineering control systems will not be effective in controlling dust levels (Ex. 17, p. 6). This provision received general acceptance by NIOSH, industry, union witnesses, and dust control equipment vendors (Ex. 16, p. IV-30; Ex. 1, p. 98; Ex. 17, pp. 5-7; and Tr. 2369). Further, good maintenance is fully within the reach of any firm and may contribute to improved productivity as well as reduction in dust levels (Ex. 16, p. IV-26; Ex. 17, pp. 7-8).

In addition to the specified work practices, the final standard also generally requires the employer to establish and implement a written program of work practices to include procedures which shall minimize cotton dust exposure for each specific job. The need for workpractice programs is well documented (Ex. 1, p. 98; Ex. 16, pp. IV-30-31). RTI referenced a work practice program for opening room operations developed by ATMI and elaborated on the importance of specific work practice programs for controlling employee exposure to cotton dust (Ex. 16, p. IV-30). The protocol utilized by ATMI in developing work practices for specific jobs consists of making a detailed analysis of the sequence of actions followed by an individual worker or work team at a work station and developing a specific work practice program from this information (Ex. 16, p. IV-31). The method employed by ATMI is reasonable, straight-forward, and provides a template for assignment of work practices at all similar work stations. Therefore, this method is recommended by OSHA for use in both the textile and nontextile industries.

The National Cotton Council of America (NCCA) expressed concern that in operations such as cotton compress warehousing where some 31 different job functions exist, formulating specific work practices for each job category could become disruptive to productivity, and could result in greater expenditures than implementation of engineering controls (Ex. 97f, pp. 24-25). NCC offered no evidence to document productivity losses, nor was any such evidence offered by any other witnesses. OSHA is, therefore, not persuaded that significant losses in productivity are an inevitable consequence of the work practice provisions of this standard. Nor does OSHA believe that work practice controls are as costly as engineering controls. Often by simply altering a ritual or unnecessary routine or correcting sloppy practices significant reduction can be acheived in dust levels to which employees are exposed.

It was argued by the Amalgated Clothing and Textile Workers Union, (Ex. 85, p. 2) that OSHA should require employers to consult with their employees or the employees' representative about the content of the written work practice program. OSHA believes that primary responsibility for implementation of the requirement that employee exposure to cotton dust be reduced below the permissible exposure limit, must be placed upon the employer, and that it is the employer's responsibility to select the appropriate work practices. Although appropriate work practice programs will likely rely in part upon information supplied by the worker to the employer, OSHA does not consider it necessary to require employers to consult in the development of the work practices.

At noted above, the final standard does specify that certain work practices be included as part of every work practice program of each covered employer. One such practice prohibits the employer from using compressed air cleaning in "blow down" operations except where alternative means are not available. Considerable comment was addressed to this requirement. Industry objected to any restriction on "blow down", arguing that no feasible alternative existed. RTI agreed that "blow down" to remove lint and dust from equipment was accomplished much more effectively with an air jet than through vacuuming, because an air jet created by a blowing nozzle maintains at least 10% of its discharge velocity at a distance equal to 30 times the diameter of the nozzle opening, whereas a vacuum pick-up requires close contact with the lint or dust to be effective (Ex. 16, p. IV-27).

Dr. John Neefus of Burlington Industries commented on vacuuming:

> Vacuum cleaning does not solve the problem. In a survey of ten plants on work practices, all had tried vacuum cleaning at one time or another. It should be noted that vacuuming does not work well in humid textile plant situations; its effectiveness is only 1/30th that of the compressed air; and from an industrial hygiene standpoint the respirable dust comes through the vacuum bag into the operational area (Ex. 49, p. 15).

Yet failure to remove lint and dust can have serious consequences for production equipment, such as breakdown or reduced efficiency (e.g. in knitting), and for the product in textile mills, such as diminished cloth quality. The failure to remove lint build ups has been shown to cause lint fires (Tr. 2005). Furthermore, industry described situations where locations were not accessible to vacuuming (Ex. 16, p. IV-27; knitting), and where the cleaning of inaccessible rafters and duct work could present a serious hazard to a worker using a vacuum cleaner (Ex. 95d, p. 6).

On the other hand, union representatives (Ex. 78 p. 2) expressed concern over the use of compressed air even when feasible alternatives are not available. They contended that the cotton industry will interpret this provision as always enabling employers to use compressed air during "blow down". Further, they maintained that blow down with compressed air results in elevated dust concentrations in the work area and, consequently, increases worker exposure.

Some parties recommended alternative approaches to vacuuming for the use of compressed air in "blow down". For instance, one alternative suggested involves blow down with compressed air being done only between shifts when production workers are not in the immediate area (Ex. 16, IV-28). Industry personnel insisted that, for some operations, "blow down" cannot be done between shifts and in fact, often must be done more than once per shift (Ex. 16, IV-28). Thus, although it may be technically feasible to perform "blow down" when production workers are not in the area, it may be disruptive to the normal production patterns (Tr. 545). In the case of knitting, "blow down" to prevent clogging of banks of knitting needles is an almost continuous necessity.

OSHA has extensively reviewed all comments and arguments presented concerning this requirement. Based on OSHA's conclusions, the final standard continues to prohibit "blow down" with compressed air except where feasible alternatives are not available. We are persuaded that in some operations where extensive enclosure of equipment has been done that vacuuming would be impractical, and yet failure to remove lint and dust from the equipment could result in a fire and consequently confront the worker with yet another hazard (Tr. 2005).

OSHA does not believe that this provision is tantamount to "blow down as usual". The ritual use of compressed air by employers is prohibited. Employers are required to limit use of "blow down" strictly to maintenance. Thus, common practices such as clean-

ing of clothes or floors with compressed air is forbidden.

OSHA is also convinced that achievement of the environmental dust limits provided in this standard will reduce the need and frequency of "blow down" in all workplaces. Neefus testified that in the cleaner textile mills he surveyed, blow down is an infrequent occurrence and, when it is used, dust levels are elevated in the immediate area for only approximately one hour (Tr. 2019).

While blow down with compressed air is permitted in some limited instances by the standard, OSHA is still concerned with the exposure of workers to elevated concentrations of cotton dust during these blow down operations. For this reason, OSHA deems it appropriate to require workers performing these operations to wear respirators and those not involved in the process to leave the area. While respirators are not the preferred method of reducing worker exposure to toxic materials, it is generally acknowledged that maintenance operations may require respirator use to provide adequate protection for the workers involved.

In addition to the provision for blow down operations, the final standard requires that all work practice programs include floor sweeping with a vacuum or a method designed to minimize dispersal of dust. Some participants suggested that an effective total ventilation system incorporated in cotton processing areas should include, as a minimum, a central vacuum system. This would allow for equipment cleaning and could serve as an integral part of an effective general housekeeping program (Ex. 17, p. 6; Ex. 1, p. 7). Industry witnesses, although not in favor of the free use of compressed air for cleaning operations (Tr. 2005) expressed concern with the position in the cotton dust proposal (Ex. 2) that vacuum cleaning solves the problem. They suggested that dust collected through vacuuming often passes through the vacuum collection bag and is forced back into the operational area. OSHA accepts industry's recommendation that lint and other materials could be successfully removed with plows and push-brooms without overtly increasing exposure to the individual (Ex. 49; Ex. 69), and therefore permits alternatives to vacuuming if they are designed to minimize dispersal of dust.

Finally, the standard requires that cotton and cotton wastes shall be stacked, sorted, baled, dumped, removed, or otherwise handled by mechanical means, except where the employer can show that it is infeasible to do so. Industry witnesses encouraged this practice where possible (Ex. 49, Tr. 2006). Current practices employ this principle as evidenced by examples given in the RTI report. Some industries have already converted from manual to mechanical handling of cotton. For instance, in the opening/cleaning operations automatic carousel type openers are used and transfer is automatically accomplished (Ex. 16, A-6); in picking operations, the tufts are fed pneumatically to the card via a chute (Ex. 16, A-9). The RTI report discussed situations where manual handling of cotton and cotton wastes currently results in excessive employee exposures. Some examples are the processing of nonwoven fabrics and surgical dressings operations requires manual handling of the cotton stock in feeding pickers, baling, and transportation of bales and laps (Ex. 16, A-44), and cottonseed oil processing excessively involving manual feeding of cottonseed to the mill and manual handling in the baling operations (Ex. 16, A-46). Union representatives indicated a preference for mechanical methods of moving cotton or cotton wastes (Ex. 78, p. 19) and advocated greater use where applicable. It is OSHA's view, reflected in the standard that employee handling of cotton or cotton waste products must be eliminated where feasible.

H. *Medical Surveillance.* The standard requires each employer to institute a medical surveillance program for all employees exposed to cotton dust. The evidence in the record amply demonstrates that a few relatively basic and easily administered screening devices can detect the development of respiratory disease in exposed employees.

The need for a medical surveillance program such as that discussed in the proposal and essentially adopted in the final standard, as well as the appropriateness of the requirements of the program, have been persuasively demonstrated by the existence of medical programs of similar scope in the textile industry (Ex. 47). The record also indicates the need for medical surveillance and its feasibility in all segments of the cotton industry (e.g. Ex. 47, pp. 1-2; Ex. 42; Ex. 46).

The standard requires the medical surveillance program be completed no later than 12 months. During the hearings representatives of the textile industry described medical programs similar to those required by this standard which were already in existence. (Ex. 47, Ex. 46, Ex. 41, Ex. 42) While many of the larger industries have developed medical surveillance programs, OSHA recognizes that in both the textile and non-textile industries many firms have not yet initiated programs. In some geographical areas a shortage of medical personnel may exist which would delay initiation of the program. Small firms may decide to pool resources and develop mobile programs which will service a number of firms in a particular area. Industry may require more time to initiate a mobile program than would be required for any single business. In general, purchase, delivery, calibration of equipment, training of medical personnel and actually initiating the program will require a start-up period especially for the large number of small businesses effected by the standard. Given these time constraints OSHA has concluded that 12 months will be required for development and implementation of medical surveillance programs.

New provisions have been added where the record indicates a need for greater standardization of the medical surveillance program, e.g. accuracy of spirometers and standardized procedures for technicians. (Ex. 38; Ex. 13, pp. 34; Ex. 40) Medical directors of several large textile companies testified that rigid requirements would cut down on flexibility. (Ex. 41, 42, 46, 47) However, as is discussed below, more persuasive considerations require some sacrifice of flexibility to insure uniform medical surveillance in all workplaces.

The final standard requires that the medical surveillance program provide each affected employee with an opportunity for medical surveillance. All examinations and procedures are required to be performed by or under the supervision of a licensed physician and provided without cost to the employee. The administration of the questionnaire and pulmonary function tests can be conducted by persons under the supervision of the physician. The record evidence supports this conclusion. (Ex. 13, p. 4; Ex. 11, pp. 8-10; Tr. 1574; Tr. 1463; Tr. 1852; Tr. 1726).

The standard provides for the administration of a standardized respiratory questionnaire at the time of initial assignment or upon institution of the medical surveillance program. Whereas the proposal mandated a version of the questionnaire designed for and used in the textile industry, the final standard also includes versions appropriate to non-textile operations. These are contained in Appendix B to the standard. Pulmonary function measurements including FVC and FEV_1 are to be performed at the same time. This initial assessment determines the fitness of each employee to be exposed to cotton dust and establishes a baseline health condition.

All employees must be provided with an opportunity for medical surveillance on an annual basis, but employees meeting criteria which demonstrate increased respiratory sensitivity must be monitored with greater frequency, i.e. after 6 months. Since these provisions appear to provide more frequent opportunity for surveillance than do the most advanced in-

dustry programs, OSHA has been criticized by industry for unduly increasing its burden (Tr. 1768). However, there was general endorsement for the proposed medical surveillance program by NIOSH (Ex. 38) and other expert medical witnesses (Ex. 11; Ex. 137), and no evidence demonstrating that less frequent medical screening will identify cotton dust induced changes in objective and subjective symptomatology with adequate thoroughness. Where no sacrifice in protection is entailed, OSHA has reduced the burden on industry, for example, by allowing use of an abbreviated questionnaire on the retest (Appendix B-III).

The preamble to the proposed cotton dust standard and the Health Effects section of this final standard amply document the need to measure both subjective and objective respiratory changes in workers exposed to cotton dust. The record demonstrates widespread reliance upon the medical questionnaire as a measure of the worker's subjective symptoms of chest tightness, dyspnea, phlegm production and cough, both in the workplace and in field studies. Despite the endorsement of the questionnaire as a mass diagnostic tool by witnesses on behalf of the cotton industry, some witnesses raised specific concerns arising out of their experience with these techniques.

A threshold question was raised as to which questionnaire is the best one for eliciting reliable symptoms (Ex. 48, pp. 4-5). NIOSH recommended a standard questionnaire based upon the British Medical Research Council questionnaire used by Schilling, Merchant, and numerous others (e.g. Tr. 1005; Tr. 1802). Medical directors testifying on behalf of ATMI, criticized specific questions on this form as "inflating" the numbers of positive responses and, therefore, the prevalence of byssinosis (Tr. 1643, 1665-7; Tr. 1851). The variability observed in the prevalence of grade 1/2 byssinosis, in which the symptoms are intermittent, Dr. Mario Battigelli believed, also may tend to increase with the use of specific questions regarding return to mill work (Ex. 48, pp. 6-7). Based on his field work, however, Merchant has responded that the reliability of the questionnaire has been corroborated by individual diagnoses performed by several physicians associated with the Duke-North Carolina Department of Health team, and that sensitivity was important (Tr. 1005). Nevertheless, even if detection of grade 1/2 byssinosis results in inflation of byssinosis prevalence, OSHA does not believe this factor impairs the function of the recommended questionnaire in the medical surveillance program, that is, the detection of employee respiratory complaints. It is preferable from a health viewpoint for the questionnaire, which is clearly put forward as a mass screening device, to be sensitive and, if necessary, to err in favor of recording symptoms which may later disappear rather than to be insufficiently sensitive and to fail to elicit subjective manifestations of lung dysfunction which may accompany progressive deterioration.

The use of other questionnaires, including some adopted by the textile industry, was also suggested (Tr. 1686). OSHA notes that all questionnaires are progeny of the BMRC questionnaire, and that there is no evidence that any of these forms is superior to the one required for textile mills by this standard. The required questionnaire has been modified by additions and deletions suggested during the hearings. Furthermore, NIOSH provided variations of the standard questionnaire to more adequately monitor populations in non-textile operations, and an abbreviated questionnaire where appropriate.

Some parties were concerned that employee familiarity with the standard questionnaire would lead to manipulation by workers once the consequences of certain responses were understood (Ex. 108, pp. 15-16). Beyond these general concerns, there was no indication as to whether workers would be more likely to suppress or to overreport symptoms. Whatever the ramifications of employee familiarity, OSHA's adoption of the abbreviated form of the standard questionnaire for retesting should reduce the problem. The scheme relies on specific respiratory system complaints (e.g., cough and chest tightness) after an initial administration of the full questionnaire. Further, the use of the abbreviated questionnaire has obvious time-saving advantages during re-examination. Most importantly, the results of the abbreviated questionnaire correlate well with the standard questionnaire (Tr. 1005).

Some of the criticism of subjective criteria presented by medical witnesses testifying on behalf of ATMI represent a preference for objective measurements of lung dysfunction. The record indicates that even the severest critics of the standard questionnaire admit this method's utility and use some form of the questionnaire (e.g., Tr. 1961-3). OSHA sees, on the one hand, little substantiated evidence detracting from the successful record compiled by use of the questionnaire. On the other hand, OSHA is convinced that subjective determinations are an integral part of any medical screening for the manifestations of cotton dust induced disease.

In addition to the use of the questionnaire, the standard requires that pulmonary function measurements be performed before the employee enters the workplace on the first day of the working week, following a period of at least 35 hours away from work. The test must be repeated following exposure of no less than 4 hours and no more than 10 hours, but in any event no more than 1 hour after cessation of exposure. An opportunity for spirometry must be provided for each employee on an annual basis thereafter, and semi-annually for those who exhibit deterioration of lung functions, as stated in the proposal. These tests can be performed quickly, simply and without discomfort to the employee.

In general, the pulmonary function testing program was well received during the hearings. Some physicians testifying for the textile industry debated the significance of the criteria used in the standard to indicate substantial pulmonary changes. On the other hand, other expert witnesses supported the pulmonary function testing criteria as required. Dr. Bouhuys suggested that a decrement of 0.2 liters in FEV_1 over a shift was a significant change (Tr. 170), whereas, for the ATMI, Drs. Harley (Tr. 1516), Imbus (Ex. 47), Martin (Tr. 1798-9), Morgan (Tr. 1354) and Whitworth (Tr. 1644) argued that only a 10 percent drop on Monday is a cause for concern. Dr. Bouhuys said that expressing the FEV_1 decrement as a percentage of the initial FEV_1 would result in unequal application of the standard. Persons with large FEV_1 would have to sustain larger absolute decrements than persons with small initial FEV_1 before they become classified as reactors. Therefore, he proposed the use of 0.20 liter drop in FEV_1 as the indicator of broncho-constrictor effect (Tr. 170). This is a slightly less stringent cut-off level for those employees whose initial FEV_1 is less than 4 liters. However, 0.20 liters decrement is a more sensitive parameter than 5 percent drop for detecting broncho-constrictor effect in workers with a larger initial FEV_1 than 4 liters.

Medical experts who testified on behalf of ATMI, argued that the proposed 5 percent decrement in FEV_1 over the shift as the indicator of acute response is too stringent because of inherent variability associated with current spirometry testing (Tr. 1516, Ex. 47 p. 11; Tr. 1798-9; Tr. 1354; Tr. 1644). They recommended that the level of significant change in FEV_1 be set at 10 percent. The testimony of several independent physicians argued, to the contrary, the need for sensitivity in any diagnostic test designed to identify a response. For example, Dr. Hans Weill has stated:

> I feel that it is too lenient to draw attention to an acute broncho-constrictor effect only if the post-shift FEV_1 has declined by 10 percent or more. For young or middle aged men, this means a drop in the FEV_1 of 350 to 400 ml, which is too large a change as a minimum. Individuals with 150 ml or 200

ml decline in ventilatory function, particularly during the morning shift, may very well be exhibiting a specific response to cotton dust. I recommend that the magnitude of FEV_1 decline be specified as either 200 ml or 5 percent or the initial FEV_1, whichever is less" (Ex. 27, p. 5).

OSHA is persuaded by the testimony of Dr. Weill and industry physicians that objective measurements are perhaps the most effective tool of the medical surveillance program and their importance could be wasted if insensitive gradations are employed.

There was some evidence supporting a requirement to monitor annual declines in pulmonary functions. Unfortunately, at the present time too little is known about general pulmonary function decline in the general population, and furthermore, the fluctuations of an individual's pulmonary function indicators may be too variable for any diagnostic purpose in the context of cotton dust exposure. Therefore, the standard does not require monitoring of annual declines in pulmonary functions.

The need for greater latitude in the percentage drop in FEV_1 and its interpretation advocated by ATMI witnesses was partly attributable to poor accuracy of pulmonary function testing in the past. Factors which contribute to variability of spirometry results are lack of uniform specification or requirement for spirometry apparatus, techniques required for calibration of equipment, and procedures for performing the tests. Further, there have been no training requirements for the technicians and other personnel performing the spirometric testing. These shortcomings of spirometry have been recognized. For example, Dr. Weill characterized spirometry as a "more objective and more sensitive" method of detecting broncho-constrictor effect than responses to a questionnaire. Yet he testified that governing spirometry equipment, personnel training and procedures for performing tests used "contribute heavily to the variability between centers, within a center and within an industrial medical department" (Tr. 312-13).

In response to this obvious need, over the last several years NIOSH has conducted extensive research in pulmonary function equipment and testing in cooperation with the American Thoracic Society (ATS), the National Heart, Lung, and Blood Institute, Food and Drug Administration, to establish recommendations. This effort has resulted in uniform spirometry standards which OSHA has included in Appendix B, as mandatory minimum standards for spirometric measurements under the cotton dust standard. These NIOSH and ATS standards include specifications for apparatus, techniques for measurements of FVC maneuver, instruction for interpretation of the spirogram, and qualifications of personnel administering the test (Appendix D). For example, the standards require that the instrument shall be accurate to within ±50 ml or within ±3% of reading, and should be capable of measuring vital capacity from 0 to 7 liters. The instrument must provide a tracing or display of either flow versus volume or volume versus time during the entire forced expiration. A tracing or display is necessary to determine whether the patient has performed the test properly. The procedure should be explained in simple terms to the patient and at least three forced expirations must be carried out. Another important specification related to interpretation of the spirogram is that "the largest observed FVC and largest observed FEV_1 shall be used in the analysis regardless of the curve(s) on which they occur".

The key to reliable pulmonary function testing is the technician's way of guiding the employee through a series of respiratory maneuvers. The most important quality of a pulmonary function technician is the motivation to do the very best test on every employee. The technician must also be able to judge the degree of effort and cooperation of the subject. The test results obtained by a technician who lacks these skills are not only useless, but also convey false information which could be harmful to the employee.

During the hearings it was generally agreed that pulmonary function tests may be performed by non-physicians, but the physician ought to make final judgments as to whether the person needs to be followed, retested or seen by another physician (Tr. p. 1574; Tr. 1803; Tr. 3410; Ex. 38). It was also established that it is common for nurses and administrative personnel to conduct testing Burlington Industries. OSHA acknowledges such programs; however, OSHA feels any person who performs medical examinations and procedures must do so under the supervision of a licensed physician and must complete a NIOSH approved training course in spirometry. The standard, therefore, contains these requirements.

Spirometry nomograms for normal subjects appearing in Appendix C of the proposal were replaced with the tables derived from Knudson et al. (Am. Rev. Resp. Dis., vol. 113, 1976). The nomograms in the proposed standard were based on Kory et al.; (Am. J. Med. 30, 243-258, 1961) data, which used male subjects only. Knudson studied randomly selected, representative populations of both sexes. NIOSH recommended the prediction formulas developed by Knudson because their testing and analysis procedures most closely matched the recent NIOSH and ATS Pulmonary Function Standards. Knudson also gives equations for both male and female "normal" non-smokers, whereas Kory included ex-smokers and smokers in his study population. The only problem with the Knudson method was their use of the average of the best two of five values; whereas, the NIOSH and ATS standard recommends the use of the largest value. Knudson did perform a comparison using both methods and found no difference in the mean FVC and FEV_1. Kory's prediction equations were not derived from methods recommended by NIOSH and ATS standards. Therefore, OSHA is of the opinion that the tables of the predicted normal values for FVC and FEV_1 developed by Knudson et al. are the most representative standards available, and these are included in Appendix C.

The standard specifies that the predicted FEV_1 and FVC for blacks should be multiplied by 0.85 to adjust for ethnic differences. Comparatives studies in general show the vital capacity of black workers to be about 15 percent less than that of white workers (Ex. 1, pp. 131-3). In the proposal, OSHA requested information on formulas which should be used for evaluating results of pulmonary function among ethnic groups in order to provide proper interpretation of spirometry measurements for blacks without inadvertently fostering discrimination in hiring practices. NIOSH addressed the issues of ethnic differences in pulmonary function measurements by introducing the use of an FEV_1 ratio as a guideline, suggesting that "ethnic differences in lung volumes, which are not well defined, may be removed from consideration in the rules by the use of the FEV_1/FVC ratio which is not affected by race" (Ex. 38, pp. 15-16). However, Dr. Bouhuys contested the validity of the ratio as a possible solution for racial difference in lung functions, stating "our own studies of some 1,800 whites and 1,200 blacks suggests that the FEV_1/FVC ratio is not necessarily the same for blacks and whites. In other words, we do not find that you can use simple scaling factors in order to correct for the racial differences in lung function" (Tr. 238). Dr. Weill also rejected the FEV_1/FVC ratio in favor of 15 percent correction (Tr. 382-2). Drs. Harley (Tr. 1587), Morgan (Tr. 1447) and Whitworth (Tr. 1644) agreed with the proposed 15 percent correction for black employees, although Dr. Martin found an 8 percent correction to describe the population (Tr. 1807-8). Since the testimony provided insufficient support for an FEV_1/FVC ratio, the 15 percent correction originally proposed by the NIOSH Ad Hoc Committee on Pulmonary Function Evaluation was adopted (Ex. 1, pp. 131-3). However, OSHA recognizes, as Dr.

Martin has testified, that this correction may not be precisely correct. Unfortunately, there is not sufficient research data to adequately guide the Agency in determining a better correction for black employees. Hence, OSHA will rely on the current state of the art in establishing the stated provision dealing with ethnic differences.

The standard provides that the employer is required to obtain a written opinion from the examining physician containing: The physician's opinion as to whether the employee has any detected medical conditions which would place the employee at increased risk of material impairment of health from exposure to cotton dust; the results of the medical examination; recommended limitations upon the employee's exposure to cotton dust and upon the use of respirators; and a statement that the employee had been informed by the physician of any medical conditions which require further examination or treatment.

The provision was of great concern to Dr. Martin (Tr. 1768-9; p. 1573) who argued that physicians cannot always detect on the initial exam "medical conditions which would place the employee at increased risk," and that there are no specific tests which physicians could rely on in giving such an opinion. It was the view of ATMI that this requirement will fail to achieve any objective other than "to tie the hands of the examining physician," and recommended greater freedom for physicians to exercise a common sense and clinical judgment. The standard does not prevent the physicians from exercising their clinical judgment, in fact, paragraphs (h)(3)(c) and (h)(5) of the standard encourage this exercise. But OSHA believes that an assessment of increased risk by the examining physician is an integral part of the medical surveillance program, and accordingly has not altered this requirement, which is common to virtually all OSHA health standards. This provision was not extensively treated at the hearings other than by ATMI and little additional evidence was adduced.

There was some concern expressed at the hearing as to the confidentiality of the workers' medical records. NIOSH specifically recommended safeguards in its prepared statement, (Ex. 39(a), p. 16), and during the hearing Merchant stated:

> "• • • Care must be taken to assure the workers that this information, personal medical information, is to be kept confidential. And this is, I think, part of the doctor-patient relationship which cannot be violated. And I think this ought to be spelled out very clearly in the provisions of the medical surveillance program which would be a part of, any part of, a standard" (Tr. 1306).

The general thrust of the comments on confidentiality was that medical findings should be kept strictly confidential between the worker and the examining physician.

The purpose of requiring the examining physician to supply a written opinion is to provide the employer with a medical basis to aid in the determination of initial placement and to provide information on a continuing basis as to whether or not the worker is at an increased risk as a result of cotton dust exposure. Requiring that the opinion be in written form will serve as an objective check that the employer has actually had the benefit of the information in making these determinations. Since the employer has the ultimate responsibility to protect the health of his employees, the standard requires that a written opinion be furnished to the employer by the examining physician. To ensure that employers are not given information about the employee's physical condition that has no relation to occupational exposure, the standard requires that the written opinion shall not reveal specific findings or diagnoses unrelated to occupational exposure.

In order to insure a confidential medical surveillance program, ACTWU (Ex. 82, pp. 11-14) suggested requiring the use of independent examining physicians. Support for this concept was offered by Merchant based upon his experiences both as an epidemiological investigator of the textile industry and the administrator of the Federal surveillance program of underground coal mines. OSHA recognizes the desirability of implementing the medical provisions of this program through an independent medical staff. One way this could be accomplished would be through the use of clinics established by the government. However, the record also identifies the existence of thousands of workplaces using cotton scattered throughout the nation. Therefore, it is not possible to provide centralized, government-sponsored clinics for all these workplaces. OSHA therefore is relying on the professional conduct of industry physicians and the patient-physician relationship to assure the appropriate level of confidentiality.

Among the issues in the cotton dust rulemaking were whether OSHA should include a mandatory removal requirement—that is, a provision prohibiting the exposure of an employee to cotton dust if the employee would be placed at increased risk of material impairment of health because of such exposure, and whether OSHA should include a medical removal protection provision—that is, a provision requiring the transfer of such employee to another job, or providing that removal for medical reasons should not result in loss of earnings to the affected employee. These issues, as OSHA has previously stated (41 FR 56507), are related and should be addressed together. Both employee (Ex. 82, pp. 14-15) and industry (Tr. 1861-3; 1882-5; Tr. 1677-80) participants expressed their views as to several aspects of these issues in testimony during the hearing. However, the final standard does not include any mandatory medical removal provision. Subsequent to the close of the hearing record in this proceeding, OSHA conducted an informal public hearing on mandatory removal and medical removal protection for workers exposed to lead, as part of the rulemaking proceeding in lead. Consideration of the critical issue of medical removal protection is being undertaken in that proceeding. Once this analysis is completed, OSHA will consider the extent to which the conclusions on medical removal protection are appropriate for cotton dust and will propose the inclusion of appropriate provisions in the cotton dust standard. The final standard published today therefore, does not address the issue of mandatory removal and medical removal protection.

I. *Employee Education and Training.* This final standard requires the employer to provide a training program for all employees exposed to cotton dust. As agreed upon by virtually all of the participants in the rulemaking proceeding, information and training are essential for the protection of employees (Ex. 38, p. 18; Ex. 54a; Ex. 82). Employees can do much to protect themselves if they are made aware of the hazards in the workplace. This is especially true in the case of occupational exposure to cotton dust where byssionsis is seen at levels approaching zero.

The proposed standard would have required employers to provide employees with access to this regulation and to inform employees of the specific nature of operations which could result in exposure at or above the permissible exposure limit. The employer was also responsible for developing and implementing employee training programs which would include information on mandated dust control measures, work practices, respirators, medical surveillance, the symptoms of respiratory diseases, and a review of the entire standard.

The content of the training program required by this final standard is intended to apprise the employees of (1) the hazards to which they are exposed, (2) the necessary steps to protect themselves, including minimizing exposure, respiratory protection and medical surveillance; (3) their role in controlling and reducing dust emissions; and (4) their rights under this standard.

The training program is required to be completed within 90 days of the effective date of this standard for employees initially covered by the stand-

ard, and for other employees at the time of initial assignment to areas where there is possibility of exposure to cotton dust. OSHA believes that it is important to train employees as soon as possible in order to maximize the benefits of the training program.

The standard requires that the training program be provided annually. OSHA believes that an annual training program is both necessary and sufficient to re-inform the employee of the hazards.

Under the provisions of this standard the employer is required to make a copy of the standard and its appendices available to affected employees. This requirement, in combination with the review provided for as part of the training program, is intended to ensure that employees understand their right and duties under this standard.

OSHA has changed the proposal which would only have required employers to make a copy of this regulation readily available, to require in addition that the employer post the regulation and its appendices in the workplace at a location which is readily accessible to the employees. David McAteer, a former United Mine Workers of America attorney, related experiences under the Federal Coal Mine Health and Safety Act which suggested that some workers are reluctant to request materials such as this from a company supervisor (Tr. 2118–19). The posting requirement resolves worker concerns, without adding any burden to the employer. Therefore, OSHA is requiring employers to post the regulation and appendices.

Several parties (Tr. 3051–2; Tr. 3100; Tr. 2102–3; Ex. 54a, pp. 16–17) testified in support of OSHA providing materials and a uniform format for employee education and training. This testimony recommended distributing written materials to employees, providing audio-visual materials, and mandating minimum time and frequency requirements for employee presentations. As a result, OSHA intends to develop, in the future, specific safety and health training and educational materials on cotton dust for distribution and presentation to employees by employers, in addition to the training requirements specified in this regulation. These materials will inform employees of the hazards of exposure to cotton dust and appropriate protective measures as discussed in this preamble and final regulation. Where these materials are designated by the Assistant Secretary, the employer will be required to include them as part of his education and training program.

The employer is also required to provide, upon request, all materials relating to the training program to the Assistant Secretary and the Director. This is intended to provide an objective check of compliance with the requirements of the standards.

J. *Signs.* The final standard requires that a warning sign be posted. The standard specifies the legend for these signs. The employer is required to post the warning signs in any work area where the permissible exposure limit for cotton dust is exceeded.

The proposal required the employer to post signs wherever respirators were required to be used. A sign warning of cotton dust exposures was not required in the proposal. However, evidence presented during the hearing clearly demonstrated the need for these additional posting provisions (Ex. 54a, pp. 18–19; Tr. 3052.) For example, Mr. Frumin, representinmg the ACTWU, argued that OSHA must adopt a provision for warning signs in order to apprise unwitting workers of hazards in their workplace. He pointed out that the lack of any warning sign requirements was a serious omission (Tr. 3052). Indeed, testimony by members of the Carolina Brown Lung Association (e.g.; Ex. 54), which represents afflicted retirees and current mill employees, demonstrated that workers often attribute occupational health problems to the wrong sources. This testimony also supports the need for the signs.

OSHA believes that it is important, and indeed section 6(b)(7) of the Act requires, that appropriate forms of warning be used to apprise employees of the hazards to which they are exposed during the course of their employment. OSHA believes as a matter of policy that employees should be given the opportunity to make informed decisions on whether to work at a job under the particular existing working conditions. Furthermore, OSHA believes that, since the control of potential safety and health problems involves the cooperation of employees, the success of such a program is highly dependent upon the worker's understanding of the hazards attendant to that job.

In light of the serious nature of the hazard of exposure to cotton dust, OSHA does not believe that periodic training alone will adequately apprise employees of the hazards. However, OSHA believes that the training coupled with requirements, the requirement to post a sign, will adequately do so.

The word "warning" is used on the sign in order to attract the attention of workers and to alert workers to the fact that they are in a potentially hazardous area.

K. *Recordkeeping.* Section 8(c)(3) of the Act (29 U.S.C. 657) mandates the inclusion of provisions requiring employers to maintain accurate records of employee exposure to potentially toxic materials and to harmful physical agents which are required to be monitored or measured. It also provides that employees or their representatives must have access to such records.

The final standard requires records of exposure measurements. The required record includes name and job classification of employees measured, details of the sampling analytic techniques, results, and type of respiratory protection worn. The standard also requires records of medical surveillance. These include names of employees, the physician's written opinion, a copy of the results of the examination, and the information furnished by the employer to the examining physician.

Participants at the hearing generally agreed with the necessity for keeping such records, but objected to the length of the record retention period.

OSHA deems it necessary that monitoring and medical surveillance data be retained for the same period because the data has to be considered together. This is consistent with OSHA's policy in other health standards (e.g. 41 FR 46782, 43 FR 5961).

OSHA has carefully considered that various suggested retention periods and has concluded that records of exposure monitoring and medical surveillance must be retained for periods of twenty years. OSHA is aware of the burden of keeping these records for this period of time. However, OSHA feels that this retention period is necessary in order to develop sufficient longitudinal dose-response data and to determine the effectiveness of the selected permissible exposure limits in reducing the prevelance of respiratory diseases, particularly irreversible chronic obstructive pulmonary diseases, in each of the covered industries.

There were participants at the hearing who argued that burden of extended recordkeeping be placed upon a government agency. However, section 8(c)(3) of the Act mandates the inclusion in occupational safety and health standards of provisions requiring employers to maintain exposure records, and section 8(c)(1) authorizes the Secretary to require employers to maintain records for research purposes. These statutory provisions indicate a congressional intent that an employer, who exposes his employees to toxic substances, must maintain records which assist in the diagnosis of disease developing from such exposure and, indeed, that such an employer has an obligation to provide the information available to him which is needed for research on the results of these exposures.

The recordkeeping provisions of this final standard reflect some changes from the proposal. This standard provides employees or their designated representatives access to the employee's medical records. This requirement

is consistent with OSHA's policy of requiring employee access, reflected in other health standards.

OSHA has also determined that retention of the regulation and appendices in each employee's file is unnecessary and, accordingly, permits retaining a master copy of these documents and reference to them in each employee's file.

This final standard, in conformity with other OSHA standards, requires that all records required to be maintained shall be made available to the Director and Assistant Secretary, that exposure records be available to the employees and their designated representatives, that exposure records which will indicate a former employee's own exposure be made available to the former employee or his designated representative, and that medical records be available to the affected employee, former employee, physician or other individial designated by an employee or former employee. These provisions, carry out the statutory requirements of section 8(c) of the Act and OSHA's policy on employee access to records enunciated in other standards (43 FR 5960-2). Briefly, it is necessary for the Assistant Secretary and Director to have access to records for enforcement and research purposes. Employees or their representatives need access to exposure records because they help the employee determine the effectiveness of the employer's exposure compliance program. The physician needs access to medical records for diagnostic purposes.

The transfer provisions are unchanged, except that records for research are no longer to be mailed by registered mail to NIOSH at the expiration of the retention period or when the employer ceases to do business. Rather, NIOSH is to be notified at the expiration of the retention period so it can determine if the records are still needed for research purposes.

L. *Observation of Monitoring.* Section 8(c)(3) if the Act requires that employers provide employees or their representatives with the opportunity to observe monitoring of employee exposure to toxic materials or harmful physical agents. In accordance with this section and consistent with the proposal and other OSHA standards, the standard contains provisions for such observation. To ensure that this right is meaningful, observers are entitled to an explanation of the measurement procedure, and to record the result obtained. The observer, whether an employee or designated representative, must be provided with, and is required to use, any personal protective devices required to be worn by employees working in the area that is being monitored, and must comply with all other applicable safety and health procedures.

M. *Effective date.* In order to ensure that affected employers and employees will be informed of the existence of the provisions of its standard, and that employers are given an opportunity to familiarize themselves and their employees with the existence of the new requirements, pursuant to section 6(b)(4) of the Act, the effective date of this standard will be September 4, 1978. As noted above, several of the provisions of standard allow additional periods of time for completion of the tasks, where such additional time is necessary. The standard sets out these dates for the various provisions.

N. *Appendices.* Appendices B,C, and D, included with this standard are incorporated as a part of this standard and impose mandatory requirements on covered employers.

Appendix A contains recommendations on methods of sampling and analysis, and, therefore, is only advisory in nature and does not by itself impose any additional obligations on covered employers.

IX. Authority

This document was prepared under the direction of Eula Bingham, Assistant Secretary of Labor for Occupational Safety and Health, 200 Constitution Ave., NW., Washington, D.C. 20210.

For all the reasons set out above, OSHA has determined, pursuant to section 6(b)(8) of the Act (84 Stat. 1594: 29 U.S.C. 655), that when compliance is achieved this new standard in § 1910.1043 will better effectuate the purposes of the Act than the existing national consensus standard reflected in 29 CFR 1910.1000, Table Z-1.

Accordingly, pursuant to sections 6(b) and 8(c) of the Occupational Safety and Health Act of 1970 (84 Stat. 1593, 1599, 29 U.S.C. 655, 657), Secretary of Labor's Order No. 8-76 (41 FR 25059), and 29 CFR Part 1911, Part 1910 of Title 29, Code of Federal Regulations is hereby amended by adding a new § 1910.1043, cotton dust, and by adding a footnote to the reference to "cotton dust (raw)" in Table Z-1 of § 1910.1000 stating: "This standard applies in cotton yarn manufacturing until compliance with § 1910.1043(c) and (e) is achieved."

In addition, pursuant to the above authority, section 4(b)(2) of the Act (84 Stat. 1592, 29 U.S.C. 653) and the specific statutes referred to in section 4(b)(2), OSHA has determined that this new standard is more effective than the corresponding standards now in subpart B of Part 1910, and in Part 1926 of Title 29, Code of Federal Regulations. Therefore, these corresponding standards are superseded by § 1910.1043. This determination and the application of the new standard to the construction industries are implemented by adding a new paragraph (f) to § 1910.19.

Signed at Washington, D.C., this 16th day of June 1978.

Eula Bingham,
Assistant Secretary of Labor.

Part 1910 of Title 29 of the Code of Federal Regulations is hereby amended as follows:

1. A new paragraph (f) is added to § 1910.19 to read as follows:

§ 1910.19 Special provisions for air contaminants.

* * * * *

(f) Section 1910.1043 shall apply to the exposure of every employee to cotton dust in every employment covered by § 1910.12, in lieu of any different standard on exposure to cotton dust which would otherwise be applicable by virtue of that section.

§ 1910.1000 [Amended]

2. Table Z-1 of § 1910.1000 is amended by adding the following footnote to "Cotton dust (raw) . . . 1 mg/m^3":

"This standard applies in cotton yarn manufacturing until compliance with § 1910.1043 (c) and (e) is achieved.

3. A new § 1910.1043 and appendices A, B, C and D are added to Part 1910, to read as follows:

§ 1910.1043 Cotton dust.

(a) *Scope and application.* (1) This section applies to the control of employee exposure to cotton dust in all workplaces, except as provided in paragraph (a)(2).

(2) This section does not apply to: (i) The harvesting of cotton; (ii) The ginning of cotton (Exposure to cotton dust in cotton ginning is covered by § 1910.1046); (iii) Maritime operations covered by 29 CFR Parts 1915, 1916, 1917, 1918; (iv) The handling or processing of woven or knitted materials; and (v) The handling or processing of washed cotton.

(3) This section provides mandatory requirements for the control of employee exposure to cotton dust. The mandatory nature of these requirements is not intended, however, to discourage or inhibit the development of different, equally effective means of providing the required protection. The variance provisions of section 6(d) of the Act, and the implementing regulations in Part 1905 of this Title, provide a mechanism for employers to obtain variances from the provisions of this section where the employers has developed alternative procedures which are "safe and healthful as" those required by this section. As implemented by the procedural regulations in Part 1905 of this Title, the variance provisions of the Act permit the flexibility which contributes to efficient compli-

ance with the standard. To aid in the expeditious processing of variance applications, the procedures allow, where appropriate, for the grant of interim orders pending a decision on the merits of the variance as well as for the consideration of variances applicable to groups of employers. OSHA encourages interested employers to utilize the variance provisions of the Act where equally safe and healthful protective means are available.

(b) *Definitions.* For the purpose of this section:

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor or designee;

"Blow down" means the cleaning of equipment and surfaces with compressed air.

"Cotton dust" means dust present in the air during the handling or processing of cotton, which may contain a mixture of many substances including ground up plant matter, fiber, bacteria, fungi, soil, pesticides, non-cotton plant matter and other contaminants which may have accumulated with the cotton during the growing, harvesting and subsequent processing or storage periods. Any dust present during the handling and processing of cotton through the weaving or knitting of fabrics, and dust present in other operations or manufacturing processes using new or waste cotton fibers or cotton fiber by-products from textile mills are considered cotton dust.

"Director" means the Director of the National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health, Education, and Welfare, or designee;

"Lint-free respirable cotton dust" means particles of cotton dust of approximately 15 microns or less aerodynamic equivalent diameter;

"Vertical elutriator cotton dust sampler" means a dust sampler which has a particle size cut-off at approximately 15 microns aerodynamic equivalent diameter when operating at the flow rate of 7.4±0.2 liters per minute;

"Yarn manufacturing" means all textile mill operations from opening to, but not including, slashing and weaving;

"Washed cotton" means cotton which has been thoroughly washed in hot water and is known in the cotton textile trade as purified or dyed. Washed cotton does not include steamed, autoclaved cotton or cotton washed solely in solvents.

(c) *Permissible exposure limits.* (1) The employer shall assure that no employee who is exposed to cotton dust in yarn manufacturing is exposed to airborne concentrations of lint-free respirable cotton dust greater than 200 ug/m³ mean concentration, averaged over an eight-hour period, as measured by a vertical elutriator or a method of equivalent accuracy and precision.

(2) The employer shall assure that no employee who is exposed to cotton dust in the textile processes known as slashing and weaving is exposed to airborne concentrations of lint-free respirable cotton dust greater than 750 ug/m³ mean concentration, averaged over any eight hour period, as measured by a vertical elutriator or a method of equivalent accuracy and precision.

(3) The employer shall assure that no employee who is exposed to cotton dust (except for exposures in yarn manufacturing and slashing and weaving covered by paragraphs (c)(1) and (c)(2)) is exposed to airborne concentrations of lint-free respirable cotton dust greater than 500 ug/m³ mean concentration, averaged over an eight-hour period, as measured by a vertical elutriator or a method of equivalent accuracy and precision.

(d) *Exposure monitoring and measurement.*—(1) *General.* (i) For the purposes of this section, employee exposure is that exposure which would occur if the employee were not using a respirator.

(ii) The sampling device to be used shall be either the vertical elutriator cotton dust sampler or a method of equivalent accuracy and precision.

(iii) If an alternative to the vertical elutriator cotton dust sampler is used, the employer shall establish equivalency by demonstrating that the alternative sampling devices;

(*a*) collect respirable particulates in the same range as the vertical elutriator (approximately 15 um);

(*b*) Replicates exposure data in side-by-side field comparisons; and

(*c*) Is equivalent within an accuracy and precision range of plus or minus 25 percent for 95 percent of the samples over the range of 0.5 to 2 times the permissible exposure limit.

(2) *Initial monitoring.* Each employer who has a place of employment in which cotton dust is present, shall conduct monitoring by obtaining measurements which are representative of the exposure of all employees to airborne concentrations of lint-free respirable cotton dust over an eight-hour period. The sampling program shall include at least one determination during each shift for each work area.

(3) *Periodic monitoring.* (i) The employer shall repeat the measurements required by paragraph (d)(2) at least every six months.

(ii) Whenever there has been a production, process, or control change which may result in new or additional exposure to cotton dust, or whenever the employer has any other reason to suspect an increase in employee exposure, the employer shall repeat the monitoring and measurements required by paragraph (d)(2) for those employees affected by the change or increase.

(4) *Employee notification.* (i) Within five working days after the receipt of monitoring results, the employer shall notify each employee in writing of the exposure measurements which represent that employee's exposure.

(ii) Whenever the results indicate that the employee's exposure exceeds the applicable permissible exposure limit specified in paragraph (c), the employer shall include in the written notice a statement that the permissible exposure limit was exceeded and a description of the corrective action taken to reduce exposure below the permissible exposure limit.

(e) *Methods of compliance (1) engineering and work practice controls.* The employer shall institute engineering and work practice controls to reduce and maintain employee exposure to cotton dust at or below the permissible exposure limit specified in paragraph (c), except to the extent that the employer establishes that such controls are not feasible.

(2) Whenever feasible engineering and work practice controls are not sufficient to reduce employee exposure to or below the permissible exposure limit, the employer shall nonetheless institute these controls to immediately reduce exposure to the lowest feasible level, and shall supplement these controls with the use of respirators which shall comply with the provisions of paragraph (f).

(3) *Compliance program.* (i) Each employer shall establish and implement a written program sufficient to reduce exposures as soon as possible to or below the permissible exposure limit solely by means of engineering controls and work practices as required by paragraph (e)(1) of this section.

(ii) The written program shall include at least the following:

(*a*) A description of each operation or process resulting in employee exposure to cotton dust;

(*b*) Engineering plans and other studies used to determine the controls for each process;

(*c*) A report of the technology considered in meeting the permissible exposure limit;

(*d*) Monitoring data obtained in accordance with paragraph (d) of this section;

(*e*) A detailed schedule for development and implementation of engineering and work practice controls, including exposure levels projected to be achieved by such controls;

(*f*) Work practice program; and

(*g*) Other relevant information.

(iii) The employer's schedule as set forth in the compliance program, shall project completion no later than September 4, 1982,

(iv) The employer shall complete the steps set forth in his program by the dates in the schedule.

(v) Written programs shall be submitted, upon request, to the Assistant Secretary and the Director, and shall be available at the worksite for examination and copying by the Assistant Secretary, the Director, and any affected employee or their designated representatives.

(vi) The written programs required under paragraph (e)(3) of this section shall be revised and updated at least every six months to reflect the current status of the program and current exposure levels.

(4) *Mechanical ventilation.* When mechanical ventilation is used to control exposure, measurements which demonstrate the effectiveness of the system to control exposure, such as capture velocity, duct velocity, or static pressure shall be made at least every six months. Measurements of the system's effectiveness to control exposures shall also be made within five days of any change in production, process or control which may result in any increase in airborne concentrations of cotton dust.

(f) *Use of respirators.*—(1) *General.* Where the use of respirators is required under this section, the employer shall provide, at no cost to the employee, and assure the use of respirators which comply with the requirements of this paragraph (f). Respirators shall be used in the following circumstances:

(i) During the time periods necessary to install or implement feasible engineering controls and work practice controls;

(ii) During maintenance and repair activities in which engineering and work practice controls are not feasible;

(iii) In work situations where feasible engineering and work practice controls are not yet sufficient to reduce exposure to or below the permissible exposure limit; and

(iv) In operations specified under paragraph (g)(1)(i).

(v) Whenever an employee requests a respirator.

(2) *Respirator selection.* (i) Where respirators are required under this section, the employer shall select the appropriate respirator from Table 1 below and shall assure that the employee uses the respirator provided.

TABLE I

Cotton dust concentration	Required respirator
Not greater than—	
(a) 5 × the applicable permissible exposure limit.	1. Any dust respirator, including single use
(b) 10 × the applicable permissible exposure limit.	1. Any dust respirator, except single use or quarter mask; or 2. Any supplied air respirator; or 3. Any self-contained breathing apparatus.
(c) 50 × the applicable permissible exposure limit.	1. High efficiency particulate filter respirator with a full facepiece; or 2. Any supplied air respirator with full-facepiece, helmet or hood; or 3. Any self-contained breathing apparatus with full-facepiece.
(d) Greater than 50 × the applicable permissible exposure limit.	1. A powered air-purifying respirator with high efficiency particulate filter; or 2. A self-contained breathing apparatus with a full facepiece operated in pressure demand or other positive pressure mode; or 3. A type "C" supplied air respirator operated in pressure demand or other positive pressure mode; or 4. A combination respirator which includes a type C supplied-air respirator which a full facepiece operated in pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure demand or other positive pressure mode.

(ii) The employer shall select respirators from those tested and approved for protection against dust by the National Institute for Occupational Safety and Health (NIOSH) under the provisions of 30 CFR Part 11.

(iii) Whenever respirators are required by this section for concentrations not greater than 5 x the applicable permissible exposure limit, the employer shall, permit the employee to use, at the employee's option, single use dust respirator in preference to any respirator specified in paragraph (a) of Table 1.

(iv) Whenever respirators are required by this section for concentrations not greater than 50 x the applicable permissible exposure limit, the employer shall, upon the request of the employee, provide a powered air purifying respirator with a high efficiency particulate filter in lieu of the respirator specified in paragraphs (a), (b), or (c) of Table I.

(v) Whenever a physician determines that an employee is unable to wear any form of respirator, including a power air purifying respirator, the employee shall be given the opportunity to transfer to another position which is available or which later becomes available having a dust level at or below the PEL. The employer shall assure than an employee who is transferred due to an inability to wear a respirator suffers no loss of earnings or other employment rights or benefits as a result of the transfer.

(vi) Until March 4, 1979, the employer shall provide any dust respirator, including single use, to all employees exposed to cotton dust, unless the employer has conducted the monitoring required by paragraph (d)(2) of this section or otherwise has monitored employee exposure. As soon as monitoring has been conducted, the employer shall select the appropriate respirator from Table I.

(3) *Respirator program.* The employer shall institute a respirator program in accordance with § 1910.134 (b), (d), (e), and (f) of this part.

(4) *Respirator usage.* (i) The employer shall assure that the respirator used by each employee exhibits minimum facepiece leakage and that the respirator is fitted properly.

(ii) The employer shall allow each employee who uses a filter respirator, to change the filter elements whenever an increase in breathing resistance is detected by the employee. The employer shall maintain an adequate supply of filter elements for this purpose.

(iii) The employer shall allow employees who wear respirators to wash their faces and respirator face pieces to prevent skin irritation associated with respirator use.

(g) *Work practices.* Each employer shall, regardless of the level of employee exposure, immediately establish and implement a written program of work practices, which shall minimize cotton dust exposure for each specific job. Where applicable, the following work practices shall be included in the work practices program:

(1) Compressed air "blow down" cleaning shall be prohibited, where alternative means are feasible. Where compressed air "blow down" is done, respirators shall be worn by the employees performing the "blow down", and employees in the area whose presence is not required to perform the "blow down" shall be required to leave the area during this cleaning operation.

(2) Cleaning of clothing or floors with compressed air shall be prohibited.

(3) Floor sweeping shall be performed with a vacuum or with methods designed to minimize dispersal of dust.

(4) Cotton and cotton waste shall be stacked, sorted, baled, dumped, removed or otherwise handled by mechanical means, except where the employer can show that it is infeasible to do so. Where infeasible, the method used for handling cotton and cotton waste shall be the method which reduces exposure to the lowest level feasible.

(5) The employer shall inspect, clean maintain, and repair, all engineering control equipment and ventilation systems including power sources, ducts, and filtration units of the equipment.

(h) *Medical surveillance.* (1) *General.* (i) Each employer who has a place

of employment in which cotton dust is present shall institute a program of medical surveillance for all employees exposed to cotton dust.

(ii) The employer shall assure that all medical examinations and procedures are performed by or under the supervision of a licensed physician and are provided without cost to the employee.

(iii) Persons other than licensed physicians, who administer the pulmonary function testing required by this section shall complete a NIOSH approved training course in spirometry.

(2) *Initial examinations.* The employer shall provide each employee who is or may be exposed to cotton dust with an opportunity for medical surveillance for new employees, this examination shall be provided prior to initial assignment. The medical surveillance shall include at least the following:

(i) A medical history;

(ii) The standardized questionnaire contained in Appendix B; and

(iii) A pulmonary function measurement, including a determination of forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1), and the percentage that the measured values of FEV and FVC differ from the predicted values, using the standard tables in Appendix C.

These determinations shall be made for each employee before the employee enters the workplace on the first day of the work week, following at least 35 hours after previous exposure to cotton dust. The tests shall be repeated during the shift, no sooner than 4 and no more than 10 hours after the beginning of the work shift; and, in any event, no more than one hour after cessation of exposure.

(iv) Based upon the questionnaire results, each employee shall be graded according to Schilling's byssinosis classification system.

(3) *Periodic examinations.* (i) The employer shall provide annual medical surveillance for all employees exposed to cotton dust which shall include at least an update of the medical history and standardized questionnaire and the pulmonary function measurements in paragraph (h)(2).

(ii) Medical surveillance as required in paragraph (h)(3)(i) shall be provided every six months for all employees in the following categories:

(*a*) An FEV_1 of greater than 80 percent of predicted, but with an FEV_1 decrement of 5 percent or 200 ml. on a first working day;

(*b*) An FEV_1 of less than 80 percent of the predicted value; or

(*c*) Where, in the opinion of the physician, any significant change in questionnaire findings, pulmonary function results, or other diagnostic tests has occured.

(iii) An employee whose FEV_1 is less than 60 percent of the predicted value shall be referred to a physician for a detailed pulmonary examination.

(iv) A comparison shall be made between the current examination results and those of previous examinations and a determination made by the physician as to whether there has been a significant change.

(4) *Information provided to the physician.* The employer shall provide the following information to the examining physician:

(i) A copy of this regulation and its Appendices;

(ii) A description of the affected employee's duties as they relate to the employee's exposure;

(iii) The employee's exposure level or anticipated exposure level;

(iv) A description of any personal protective equipment used or to be used; and

(v) Information from previous medical examinations of the affected employee which is not readily available to the examining physician.

(5) *Physician's written opinion.*

(i) The employer shall obtain and furnish the employee with a copy of a written opinion from the examining physician containing the following:

(*a*) The results of the medical examination and tests;

(*b*) The physician's opinion as to whether the employee has any detected medical conditions which would place the employee at increased risk of material impairment of the employee's health from exposure to cotton dust;

(*c*) The physician's recommended limitations upon the employee's exposure to cotton dust or upon the employee's use of respirators including a determination of whether an employee can wear a negative pressure respirator, and he cannot, a determination of the employee's ability to wear a powered air purifying respirator; and,

(*d*) A statement that the employee has been informed by the physician of the results of the medical examination and any medical conditions which require further examination or treatment.

(ii) The written opinion obtained by the employer shall not reveal specific findings or diagnoses unrelated to occupational exposure.

(i) *Employee education and training.*

(1) *Training program.* (i) The employer shall provide a training program for all employees in all workplaces where cotton dust is present, and shall assure that each employee in these workplaces is informed of the following:

(*a*) The specific nature of the operations which could result in exposure to cotton dust at or above the permissible exposure limit;

(*b*) The measures, including work practices required by paragraph (g) of this section, necessary to protect the employee from exposures in excess of the permissible exposure limit;

(*c*) The purpose, proper use and limitations of respirators required by paragraph (*f*) of this section;

(*d*) The purpose for and a description of the medical surveillance program required by paragraph (h) of this section and other information which will aid exposed employees in understanding the hazards of cotton dust exposure; and

(*e*) The contents of this standard and its appendices.

(i) The training program shall be provided prior to initial assignment and shall be reported and shall be repeated at least annually.

(2) *Access to training materials.* (i) Each employer shall post a copy of this section with its appendices in a public location at the workplace, and shall, upon request, make copies available to employees.

(ii) The employer shall provide all materials relating to the employee training and information program to the Assistant Secretary and the Director upon request.

(iii) In addition to the information required by paragraph (i)(1), the employer shall include as part of the training program, and shall distribute to employees, any materials, pertaining to the Occupational Safety and Health Act, the regulations issued pursuant to that Act, and this cotton dust standard, which are made available to the employer by the Assistant Secretary.

(j) *Signs.* The employer shall post the following warning signs in each work area where the permissible exposure limit for cotton dust is exceeded:

WARNING

COTTON DUST WORK AREA

May Cause Acute or Delayed Lung Injury

(Byssinosis)

RESPIRATORS

REQUIRED IN THIS AREA

(k) *Recordkeeping.* (1) *Exposure measurements.* (i) The employer shall establish and maintain an accurate record of all measurements required by paragraph (d) of this section.

(ii) The record shall include: (*a*) A log containing the items listed in paragraph IV (a) of Appendix A, and the dates, number, duration, and results of each of the samples taken, including a description of the procedure used to determine representative employee exposures;

(*b*) The type of protective devices worn, if any, and length of time worn; and

(*c*) The name, social security numbers, job classification, and exposure levels of employees whose exposure

the measurement is intended to represent.

(iii) The employer shall maintain this record for at least 20 years.

(2) *Medical surveillance.* (i) The employer shall establish and maintain an accurate medical record for each employee subject to medical surveillance required by paragraph (h) of this section.

(ii) The record shall include:

(*a*) The name and social security number and description of the duties of the employee;

(*b*) A copy of the medical examination results including the medical history, questionnaire responses, results of all tests, and the physician's recommendation;

(*c*) A copy of the physician's written opinion;

(*d*) Any employee medical complaints related to exposure to cotton dust;

(*e*) A copy of this standard and its appendices, except that the employer may keep one copy of the standard and the appendices for all employees, provided that he references the standard and appendices in the medical surveillance record of each employee; and

(*f*) A copy of the information provided to the physician as required by paragraphs (h)(4) of this section.

(iii) The employer shall maintain this record for at least 20 years.

(3) *Availability.* (i) The employer shall make all records required to be maintained by paragraph (k) of this section available to the Assistant Secretary and the Director for examination and copying.

(ii) The employer shall make employee exposure measurement records required by this section available to affected employees or their designated representatives for examination and copying.

(iii) The employer shall make all records as will indicate a former employee's own exposure to cotton dust available to the former employee or his designated representative for examination and copying.

(iv) The employer shall make an employee's medical records required to be maintained by this section, available to the affected employee or former employee or to a physician or other individual designated by such affected employee or former employees, for examination and copying.

(4) *Transfer of records.* (i) Whenever the employer ceases to do business, the successor employer shall receive and retain all records required to be maintained by paragraph (k) of this section.

(ii) Whenever the employer ceases to do business, and there is no successor employer to receive and retain the records for the prescribed period, these records shall be transmitted to the Director.

(iii) At the expiration of the retention period for the records required to be maintained by this section, the employer shall notify the Director at least 3 months prior to the disposal of such records and shall transmit those records to the Director if he requests them within that period.

(l) *Observation of monitoring.* (1) The employer shall provide affected employees or their designated representatives an opportunity to observe any measuring or monitoring of employee exposure to cotton dust conducted pursuant to paragraph (d) of this section.

(2) Whenever observation of the measuring or monitoring of employee exposure to cotton dust requires entry into an area where the use of personal protective equipment is required, the employer shall provide the observer with and assure the use of such equipment and shall require the observer to comply with all other applicable safety and health procedures.

(3) Without interfering with the measurement, observers shall be entitled to:

(i) An explanation of the measurement procedures;

(ii) An opportunity to observe all steps related to the measurement of airborne concentrations of cotton dust performed at the place of exposure; and

(iii) An opportunity to record the results obtained.

(m) *Effective date.*—(1) *General.* This section is effective September 4, 1978, except as otherwise provided below.

(2) *Startup dates.* (i) *Initial monitoring.* The initial monitoring required by paragraph (d)(2) of this section shall be completed as soon as possible but no later than March 4, 1979.

(ii) *Methods of compliance: engineering and work practice controls.* The engineering and work practice controls required by paragraph (e) of this section shall be implemented no later than September 4, 1982.

(iii) *Compliance program.* The compliance program required by paragraph (e)(3) of this section shall be established no later than September 4, 1979.

(iv) *Respirators.* The respirators required by paragraph (f) of this section shall be provided no later than October 4, 1978. Until September 4, 1979, the provisions of paragraph (f)(2)(iv) apply.

(v) *Work practices.* The work practices required by paragraph (g) of this section shall be implemented no later than December 4, 1978.

(vi) *Medical surveillance.* This initial medical surveillance required by paragraph (h) of this section shall be completed no later than September 4, 1979.

(vii) *Employee education and training.* The initial education and training required by paragraph (i) of this section shall be completed as soon as possible but no later than December 4, 1978.

(n) *Appendices.* (i) Appendices B, C, and D to this section are incorporated as part of this section and the contents of these appendices are mandatory.

(ii) Appendix A contains information which is not intended to create any additional obligations not otherwise imposed or to detract from any existing obligations.

APPENDIX A—AIR SAMPLING AND ANALYTICAL PROCEDURES FOR DETERMINING CONCENTRATIONS OF COTTON DUST

I. SAMPLING LOCATIONS

The sampling procedures must be designed so that samples of the actual dust concentrations are collected accurately and consistently and reflect the concentrations of dust at the place and time of sampling. Sufficient number of 6-hour area samples in each distinct work area of the plant should be collected at locations which provide representative samples of air to which the worker is exposed. In order to avoid filter overloading, sampling time may be shortened when sampling in dusty areas. Samples in each work area should be gathered simultaneously or sequentially during a normal operating period. The daily time-weighted average (TWA) exposure of each worker can then be determined by using the following formula:

$$\frac{\text{Summation of hours spent in each location and the dust concentration in that location.}}{\text{Total hours exposed}}$$

A time-weighted average concentration should be computed for each worker and properly logged and maintained on file for review.

II. SAMPLING EQUIPMENT

(a) Sampler. The instrument selected for monitoring is the Lumsden-Lynch vertical elutriator. It should operate at a flow rate of 7.4±0.2 liters/minute.

The samplers should be cleaned prior to sampling. The pumps should be monitored during sampling.

(b) Filter Holder. A three-piece cassette constructed of polystyrene designed to hold a 37-mm diameter filter should be used. Care must be exercised to insure that an adequate seal exists between elements of the cassette.

(c) Filers and Support Pads. The membrane filters used should be polyvinyl chloride with a 5-um pore size and 37-mm diameter. A support pad, commonly called a backup pad, should be used under the filter membrane in the field monitor cassette.

(d) Balance. A balance sensitive to 10 micrograms should be used.

III. INSTRUMENT CALIBRATION PROCEDURE

Samplers shall be calibrated when first received from the factory, after repair, and after receiving any abuse. The samplers should be calibrated in the laboratory both before they are used in the field and after they have been used to collect a large

number of field samples. The primary standard, such as a spirometer or other standard calibrating instruments such as a wet test meter or a large bubble meter or dry gas meter, should be used. Instructions for calibration with the wet test meter follow. If another calibration device is selected, equivalent procedures should be used:

(a) Level wet test meter. Check the water level which should just touch the calibration point at the left side of the meter. If water level is low, add water 1-2° F. warmer than room temperature of till point. Run the meter for 30 minutes before calibration;

(b) Place the polyvinyl chloride membrane filter in the filter cassette;

(c) Assemble the calibration sampling train;

(d) Connect the wet test meter to the train.

The pointer on the meter should run clockwise and a pressure drop of not more than 1.0 inch of water indicated. If the pressure drop is greater than 1.0, disconnect and check the system;

(e) Operate the system for ten minutes before starting the calibration;

(f) Check the vacuum gauge on the pump to insure that the pressure drop across the orifice exceeds 16 inches of mercury;

(g) Record the following on calibration data sheets:

(1) Wet test meter reading, start and finish;

(2) Elapsed time, start and finish (at least two minutes);

(3) Pressure drop at manometer;

(4) Air temperature;

(5) Barometric pressure; and

(6) Limiting orifice number;

(h) Calculate the flow rate and compare against the flow of 7.4±0.2 liters/minute. If flow is between these limits, perform calibration again, average results, and record orifice number and flow rate. If flow is not within these limits, discard or modify orifice and repeat procedure;

(i) Record the name of the person performing the calibration, the date, serial number of the wet test meter, and the number of the critical orifices being calibrated.

IV. SAMPLING PROCEDURE

(a) Sampling data sheets should include a log of:

(1) The date of the sample collection;

(2) The time of sampling;

(3) The location of the sampler;

(4) The sampler serial number;

(5) The cassette number;

(6) The time of starting and stopping the sampling and the duration of sampling;

(7) The weight of the filter before and after sampling;

(8) The weight of dust collected (corrected for controls);

(9) The dust concentration measured;

(10) Other pertinent information; and

(11) Name of person taking sample

(b) Assembly of filter cassette should be as follows:

(1) Loosely assemble 3-piece cassette;

(2) Number cassette;

(3) Place absorbant pad in cassette;

(4) Weigh filter to an accuracy of 10 μg;

(5) Place filter in cassette;

(6) Record weight of filter in log, using cassette number for identification;

(7) Fully assemble cassette, using pressure to force parts tightly together;

(8) Install plugs top and bottom;

(9) Put shrink band on cassette, covering joint between center and bottom parts of cassette; and

(10) Set cassette aside until shrink band dries thoroughly.

(c) Sampling collection should be performed as follows:

(1) Clean lint out of the motor and elutriator;

(2) Install vertical elutriator in sampling locations specified above with inlet 4½ to 5½ feet from floor (breathing zone height);

(3) Remove top section of cassette;

(4) Install cassette in ferrule of elutriator;

(5) Tape cassette to ferrule with masking tape or similar material for air-tight seal;

(6) Remove bottom plug of cassette and attach hose containing critical orifice;

(7) Start elutriator pump and check to see if gauge reads above 14 in. of Hg vacuum;

(8) Record starting time, cassette number, and sampler number;

(9) At end of sampling period stop pump and record time; and

(10) Controls with each batch of samples collected, two additional filter cassettes should be subjected to exactly the same handling as the samples, except that they are not opened. These control filters should be weighed in the same manner as the sample filters.

Any difference in weight in the control filters would indicate that the procedure for handling sample filters may not be adequate and should be evaluated to ascertain the cause of the difference, whether and what necessary corrections must be made, and whether additional samples must be collected.

(d) Shipping. The cassette with samples should be collected, along with the appropriate number of blanks, and shipped to the analytical laboratory in a suitable container to prevent damage in transit.

(e) Weighing of the sample should be achieved as follows:

(1) Remove shrink band:

(2) Remove top and middle sections of cassette and botton plug;

(3) Remove filter from cassette and weigh to an accuracy of 10 μg; and

(4) Record weight in log against original weight

(f) Calculation of volume of air sampled should be determined as follows:

(1) From starting and stopping times of sampling period, determine length of time in minutes of sampling period; and

(2) Multiply sampling time in minutes by flow rate of critical orifice in liters per minute and divide by 1000 to find air quantity in cubic meters.

(g) Calculation of Dust Concentrations should be made as follows:

(1) Substract weight of clean filter from dirty filter and apply control correction to find actual weight of sample. Record this weight (in μg) in log; and

(2) Divide mass of sample in μg by air volume in cubic meters to find dust concentration in μg/m. Record in log.

APPENDIX B-I
RESPIRATORY QUESTIONNAIRE

A. IDENTIFICATION DATA

PLANT _____ SOCIAL SECURITY NO. _____
DAY MONTH (figures) YEAR (last 2 digits)

NAME _____ DATE OF INTERVIEW _____
(Surname)

_____ _____ DATE OF BIRTH _____
(First Names) M F

ADDRESS _____ AGE _____ (8,9) SEX _____ (10)

RACE W N IND. OTHER (11)

INTERVIEWER: 1 2 3 4 5 6 7 8 (12)

WORK SHIFT: 1st _____ 2nd _____ 3rd _____ (13) STANDING HEIGHT _____ (14,15)

PRESENT WORK AREA WEIGHT _____ (16,18)

If working in more than one specified work area, X area where most of the work shift is spent. If "other," but spending 25% of the work shift in one of the specified work areas, classify in that work area. If carding department employee, check area within that department where most of the work shift is spent (if in doubt, check "throughout"). For work areas such as spinning and weaving where many work rooms may be involved, be sure to check the specific work room to which employee is assigned — if he works in more than one work room within a department classify as 7 (all) for that department.

	Workroom Number	(19) Open	(20) Pick	Area	(21) Card #1	(22) #2	(23) Spin	(24) Wind	(25) Twist	(26) Spool	(27) Warp	(28) Slash	(29) Weave	(30) Other
AT RISK (cotton & cotton blend)	1			Cards										
	2			Draw										
	3			Comb										
	4			Rove										
	5 —			Thru Out										
	6													
	7 — (all)													
Control (synthetic & wool)	8													
Ex-Worker (cotton)	9													

Use actual wording of each question. Put X in appropriate square after each question. When in doubt record 'No'. When no square, circle appropriate answer.

B. COUGH

Do you usually cough first thing in the morning? (on getting up)† Yes___ No___ (31)
(Count a cough with first smoke or on "first going out of doors." Exclude clearing throat or a single cough.)

Do you usually cough during the day or at night? Yes___ No___ (32)
(Ignore an occasional cough.)

If 'Yes' to either question (31-32):

Do you cough like this on most days for as much as three months a year? Yes___ No___ (33)

Do you cough on any particular day of the week? Yes___ No___ (34)

(1) (2) (3) (4) (5) (6) (7)

If 'Yes': Which day? Mon. Tues. Wed. Thur. Fri. Sat Sun. (35)

C. PHLEGM or alternative word to suit local custom.

Do you usually bring up any phlegm from your chest first thing in the morning? (Count phlegm with the first smoke or on "first going out of doors." Exclude phlegm from the nose. Count swallowed phlegm.) (on getting up)† Yes___ No___ (36)

Do you usually bring up any phlegm from your chest during the day or at night? (Accept twice or more.) Yes___ No___ (37)

If 'Yes' to either question (36) or (37):

Do you bring up phlegm like this on most days for as much as three months each year? Yes___ No___ (38)

If 'Yes' to question (33) or (38):

How long have you had this phlegm? (cough)
(Write in number of years

(1) ☐ 2 years or less
(2) ☐ More than 2 years-9 years
(3) ☐ 10-19 years
(4) ☐ 20+ years

†These words are for subjects who work at night

D. CHEST ILLNESSES

In the past three years, have you had a period of (increased) †cough and phlegm lasting for 3 weeks or more?

(1) ☐ No (40)
(2) ☐ Yes, only one period
(3) ☐ Yes, two or more periods

†For subjects who usually have phlegm

During the past 3 years have you had any chest illness which has kept you off work, indoors at home or in bed? (For as long as one week, flu?) Yes___ No___ (41)

If 'Yes' to (41): Did you bring up (more) phlegm than usual in any of these illnesses? Yes___ No___ (42)

If 'Yes' to (42): During the past three years have you had:
Only one such illness with increased phlegm? (1) ☐ (43)
More than one such illness: (2) ☐ (44)

Br. Grade___

E. TIGHTNESS

Does your chest ever feel tight or your breathing become difficult?_____Yes_____No____(45)

Is your chest tight or your breathing difficult on any particular day of the week? (after a week or 10 days away from the mill)_____Yes_____No____(46)

If 'Yes': Which day? Mon. (1) Tues. (2) Wed. (3) Thur. (4) Fri. (5) Sat. (6) Sun. (7) (8) (47)

(1) Sometimes (2) Always

If 'Yes' Monday: At what time on Monday does your chest feel tight or your breathing difficult? 1 ☐ Before entering the mill 2 ☐ After entering the mill (48)

(Ask only if NO to Question (45))

In the past, has your chest ever been tight or your breathing difficult on any particular day of the week?_____Yes_____No____(49)

If 'Yes': Which day? Mon. (1) Tues. (2) Wed. (3) Thur. (4) Fri. (5) Sat. (6) Sun. (7) (8) (50)

(1) Sometimes (2) Always

F. BREATHLESSNESS

If disabled from walking by any condition other than heart or lung disease put "X" here and leave questions (52-60) unasked. ☐ (51)

Are you ever troubled by shortness of breath, when hurrying on the level or walking up a slight hill?_____Yes_____No____(52)

If 'No', grade is 1. If 'Yes' proceed to next question

Do you get short of breath walking with other people at an ordinary pace on the level?_____Yes_____No____(53)

If 'No', grade is 2. If 'Yes', proceed to next question

Do you have to stop for breath when walking at your own pace on the level?_____Yes_____No____(54)

If 'No', grade is 3. If 'Yes', proceed to next question

Are you short of breath on washing or dressing?_____Yes_____No____(55)

If 'No', grade is 4. If 'Yes', grade is 5.

Dyspnea Grd._____(56)

ON MONDAYS:

Are you ever troubled by shortness of breath, when hurrying on the level or walking up a slight hill?_____Yes_____No____(57)

If 'No', grade is 1. If 'Yes', proceed to next question

Do you get short of breath walking with other people at an ordinary pace on the level?_____Yes_____No____(58)

If 'No', grade is 2. If 'Yes', proceed to next question

Do you have to stop for breath when walking at your own pace on the level?_____Yes_____No____(59)

If 'No', grade is 3. If 'Yes', proceed to next question

Are you short of breath on washing or dressing?_____Yes_____No____(60)

If 'No', grade is 4. If 'Yes', grade is 5

B. Grd._____(61)

G. OTHER ILLNESSES AND ALLERGY HISTORY

Do you have a heart condition for which you are under a doctor's care? ____Yes ____No ____(62)

Have you ever had asthma? Yes No (63)

If 'Yes', did it begin: (1) ☐ Before age 30

(2) ☐ After age 30

If 'Yes' before 30: did you have asthma before ever going to work in a textile mill? ____Yes ____No ____(64)

Have you ever had hay fever or other allergies (other than above)? ____Yes ____No ____(65)

H. TOBACCO SMOKING*

Do you smoke?

Record 'Yes' if regular smoker up to one month ago. (Cigarettes, cigar or pipe) ____Yes ____No ____(66)

If 'No' to (63).

Have you ever smoked? (Cigarettes, cigars, pipe. Record 'No' if subject has never smoked as much as one cigarette a day, or 1 oz. of tobacco a month, for as long as one year.) ____Yes ____No ____(67)

If 'Yes' to (63) or (64); what have you smoked and for how many years? (Write in specific number of years in the appropriate square)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
Years	(<5)	(5-9)	(10-14)	(15-19)	(20-24)	(25-29)	(30-34)	(35-39)	(>40)	
Cigarettes										(68)
Pipe										(69)
Cigars										(70)

If cigarettes, how many packs per day? (Write in number of cigarettes)

(1) ☐ less than 1/2 pack (71)
(2) ☐ 1/2 pack, but less than 1 pack
(3) ☐ 1 pack, but less than 1-1/2 packs
(4) ☐ 1-1/2 packs or more

Number of pack years: ____(72,73)

If an ex-smoker (cigarettes, cigar or pipe), how long since you stopped? (Write in number of years) ____(74)

(1) ☐ 0-1 year
(2) ☐ 1-4 years
(3) ☐ 5-9 years
(4) ☐ 10+ years

*Have you changed your smoking habits since last interview? If yes, specify what changes.

I. OCCUPATIONAL HISTORY**

Have you ever worked in: A foundry? (As long as one year) ____Yes ____No ____(75)

Stone or mineral mining, quarrying or processing? (As long as one year) ____Yes ____No ____(76)

Asbestos milling or processing? (Ever) ____Yes ____No ____(77)

Other dusts, fumes or smoke? If yes, specify: ____Yes ____No ____(78)

Type of exposure ____

Length of exposure ____

**Ask only on first interview.

At what age did you first go to work in a textile mill? (Write in specific age in appropriate square).

(1)	(2)	(3)	(4)	(5)	(6)
<20	20-24	25-29	30-34	35-39	40+

(79)

When you first worked in a textile mill, did you work with (1) ☐ Cotton or cotton blend (80)

(2) ☐ Synthetic or wool

APPENDIX B-II

Respiratory Questionnaire
for
Non-Textile Workers for the
Cotton Industry

Identification No. Interviewer Code

Location Date of Interview

A. IDENTIFICATION

1. NAME (Last) (First) (Middle Initial)

3. PHONE NUMBER AREA CODE ( ) NO.

4. SOCIAL SECURITY # (optional see below)

2. CURRENT ADDRESS (Number, Street, or Rural Route, City or Town, County, State, Zip Code)

5. BIRTHDATE (Mo., Day, Yr.)

6. AGE LAST BIRTHDAY

7. SEX

1 ☐ Male 2 ☐ Female

8. ETHNIC GROUP OR ANCESTRY

1. ☐ White, not of Hispanic Origin
2. ☐ Black, not of Hispanic Origin
3. ☐ Hispanic
4. ☐ American Indian or Alaskan Native
5. ☐ Asian or Pacific Islander
6. ☐ Other: _____

9. STANDING HEIGHT _____ (cm)

10. WEIGHT _____

11. WORK SHIFT

1st ☐ 2nd ☐ 3rd ☐

12. PRESENT WORK AREA

Please indicate primary assigned work area and percent of time spent at that site. If at other locations, please indicate and note percent of time for each.

PRIMARY WORK AREA	
SPECIFIC JOB	

13. APPROPRIATE INDUSTRY

1 ☐ Garnetting
2 ☐ Cottonseed Oil Mill
3 ☐ Cotton Warehouse
4 ☐ Utilization
5 ☐ Cotton Classification
6 ☐ Cotton Ginning

(Furnishing your Social Security number is voluntary. Your refusal to provide this number will not affect any right, benefit, or privilege to which you would be entitled if you did provide your Social Security number. Your Social Security number is being requested since it will permit use in future determinations in statistical research studies.)

B. OCCUPATIONAL HISTORY TABLE

Complete the following table showing the entire work history of the individual from present to initial employment. Sporadic, part-time periods of employment, each of no significant duration, should be grouped if possible.

INDUSTRY AND LOCATION	TENURE OF EMPLOYMENT		SPECIFIC OCCUPATION	AVERAGE NO. DAYS WORKED PER WEEK	HAZARDOUS HEALTH EXPOSURE ASSOCIATED WITH WORK		
	FROM 19__	TO 19__			YES	NO	IF YES, DESCRIBE

C. SYMPTOMS

Use actual wording of each question. Put X in appropriate square after each question. When in doubt record "No".

COUGH

1. Do you usually cough first thing in the morning? (on getting up)* (Count a cough with first smoke or on "first going out of doors". Exclude clearing throat or a single cough.) 1 ☐ Yes 2 ☐ No

2. Do you usually cough during the day or at night? (Ignore an occasional cough.) 1 ☐ Yes 2 ☐ No

If YES to either question 1 or 2:

3. Do you cough like this on most days for as much as three months a year? 1 ☐ Yes 2 ☐ No 9 ☐ NA

4. Do you cough on any particular day of the week? 1 ☐ Yes 2 ☐ No

If YES:

5. Which day? Mon. Tue. Wed. Thur. Fri. Sat. Sun. _____

PHLEGM

6. Do you usually bring up any phlegm from your chest first thing in the morning? (on getting up)* (Count phlegm with the first smoke or on "first going out of doors." Exclude phlegm from the nose. Count swallowed phlegm.) 1 ☐ Yes 2 ☐ No

7. Do you usually bring up any phlegm from your chest during the day or at night? (Accept twice or more.) 1 ☐ Yes 2 ☐ No

If YES to either question 6 or 7:

8. Do you bring up phlegm like this on most days for as much as three months each year? 1 ☐ Yes 2 ☐ No

If YES to question 3 or 8:

9. How long have you had this phlegm? (cough) (Write in number of years)

(1) ☐ 2 years or less
(2) ☐ More than 2 years - 9 years
(3) ☐ 10-19 years
(4) ☐ 20+ years

*These words are for subjects who work at night

CHEST ILLNESS

10. In the past three years, have you had a period of (increased) cough and phlegm lasting for 3 weeks or more?
(1) ☐ No
(2) ☐ Yes, only one period
(3) ☐ Yes, two or more periods

For subjects who usually have phlegm:

11. During the past 3 years have you had any chest illness which has kept you off work, indoors at home or in bed? (For as long as one week, flu?) 1 ☐ Yes 2 ☐ No

If YES to 11:

12. Did you bring up (more) phelgm than usual in any of these illnesses? 1 ☐ Yes 2 ☐ No

If YES to 12: During the past three years have you had:

13. Only one such illness with increased phelgm? 1 ☐ Yes 2 ☐ No

14. More than one such illness: 1 ☐ Yes 2 ☐ No

Br. Brade _____

TIGHTNESS

15. Does your chest ever feel tight or your breathing become difficult? 1 ☐ Yes 2 ☐ No

16. Is your chest tight or your breathing difficult on any particular day of the week? (after a week or 10 days away from the mill) 1 ☐ Yes 2 ☐ No

17. If YES, Which day? Mon. (1) Sometimes (2) Always Tues. (3) Wed. (4) Thur. (5) Fri. (6) Sat. (7) Sun. (8)

18. If YES Monday: At what time on Monday does your chest feel tight or your breathing difficult?
☐ Before entering mill
☐ After entering mill

(ASK ONLY IF NO TO QUESTION 15)

19. In the past, has your chest ever been tight or your breathing difficult on any particular day of the week? 1 ☐ Yes 2 ☐ No

20. If YES, Which day? Mon. (1) Sometimes (2) Always Tues. (3) Wed. (4) Thur. (5) Fri. (6) Sat. (7) Sun. (8)

BREATHLESSNESS

21. If disabled from walking by any condition other than heart or lung disease put "X" in the space and leave questions (22-30) unasked. ☐

22. Are you ever troubled by shortness of breath, when hurrying on the level or walking up a slight hill? 1 ☐ Yes 2 ☐ No

If NO, grade is 1. If YES, proceed to next question

23. Do you get short of breath walking with other people at an ordinary pace on the level? 1 ☐ Yes 2 ☐ No

If NO, grade is 2. If YES, proceed to next question

24. Do you have to stop for breath when walking at your own pace on the level? 1 ☐ Yes 2 ☐ No

If NO, grade is 3. If YES, proceed to next question

25. Are you short of breath on washing or dressing? 1 ☐ Yes 2 ☐ No

If NO, grade is 4. If YES, grade is 5.

26. Dyspnea Grd. _____

ON MONDAYS:

27. Are you ever troubled by shortness of breath, when hurrying on the level or walking up a slight hill? 1 ☐ Yes 2 ☐ No

If NO, grade is 1. If YES, proceed to next question

28. Do you get short of breath walking with other people at an ordinary pace on the level? 1 ☐ Yes 2 ☐ No

If NO, grade is 2, If YES, proceed to next question

29. Do you have to stop for breath when walking at your own pace on the level? 1 ☐ Yes 2 ☐ No

If NO, grade is 3. If YES, proceed to next question

30. Are you short of breath on washing or dressing? 1 ☐ Yes 2 ☐ No

If NO, grade is 4. If YES, grade is 5

31. B. Grd. _____

OTHER ILLNESSES AND ALLERGY HISTORY

32. Do you have a heart condition for which you are under a doctor's care? 1 ☐ Yes 2 ☐ No

OTHER ILLNESSES AND ALLERGY HISTORY CONTINUED:

33. Have you ever had asthma? 1 ☐ Yes 2 ☐ No

If yes, did it begin: (1) Before age 30 ☐

(2) After age 30 ☐

34. If yes before 30: did you have asthma before ever going to work in a textile mill? 1 ☐ Yes 2 ☐ No

35. Have you ever had hay fever or other allergies (other than above)? 1 ☐ Yes 2 ☐ No

TOBACCO SMOKING

36. Do you smoke? Record Yes if regular smoker up to one month ago. (Cigarettes, cigar or pipe) 1 ☐ Yes 2 ☐ No

If NO to (33).

37. Have you ever smoked? (Cigarettes, cigars, pipe. Record NO if subject has never smoked as much as one cigarette a day, or 1 oz. of tobacco a month, for as long as one year.) 1 ☐ Yes 2 ☐ No

If Yes to (33) or (34); what have you smoked for how many years? (Write in specific number of years in the appropriate square)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Years	(<5)	(5-9)	(10-14)	(15-19)	(20-24)	(25-29)	(30-34)	(35-39)	(>40)
38. Cigarettes									
39. Pipe									
40. Cigars									

41. If cigarettes, how many packs per day? Write in number of cigarettes _____

☐ Less than 1/2 pack
☐ 1/2 pack, but less than 1 pack
☐ 1 pack, but less than 1 1/2 packs
☐ 1-1/2 packs or more

42. Number of pack years: _____

43. If an ex-smoker (cigarettes, cigar or pipe), how long since you stopped? (Write in number of years.) _____

☐ 0-1 year
☐ 1-4 years
☐ 5-9 years
☐ 10+ years

OCCUPATIONAL HISTORY

Have you ever worked in:

44. A foundry? (As long as one year) 1 ☐ Yes 2 ☐ No

45. Stone or mineral mining, quarrying or processing? (As long as one year) 1 ☐ Yes 2 ☐ No

46. Asbestos milling or processing? (Ever) 1 ☐ Yes 2 ☐ No

47. Cotton or cotton blend mill? (For controls only) 1 ☐ Yes 2 ☐ No

48. Other dusts, fumes or smoke? If yes, specify. 1 ☐ Yes 2 ☐ No

Type of exposure _____

Length of exposure _____

APPENDIX B-III

ABBREVIATED RESPIRATORY QUESTIONNAIRE

A. IDENTIFICATION DATA

PLANT _____ SOCIAL SECURITY NO. _____

DAY MONTH (figures) YEAR (last 2 digits)

NAME _____ DATE OF INTERVIEW _____
(Surname)

_____ _____ DATE OF BIRTH _____
(First Names) M F

ADDRESS _____ AGE _____ (8,9) SEX _____ (10)

_____ RACE W N IND. OTHER (11)

INTERVIEWER: 1 2 3 4 5 6 7 8 (12)

WORK SHIFT: 1st _____ 2nd _____ 3rd _____ (13) STANDING HEIGHT _____ (14,15)

PRESENT WORK AREA WEIGHT _____ (16,18)

If working in more than one specified work area, X area where most of the work shift is spent. If "other," but spending 25% of the work shift in one of the specified work areas, classify in that work area. If carding department employee, check area within that department where most of the work shift is spent (if in doubt, check "throughout"). For work areas such as spinning and weaving where many work rooms may be involved, be sure to check the specific work room to which employee is assigned — if he works in more than one work room within a department classify as 7 (all) for that department.

	Workroom Number	(19) Open	(20) Pick	Area	(21) Card #1	(22) #2	(23) Spin	(24) Wind	(25) Twist	(25) Spool	(27) Warp	(28) Slash	(29) Weave	(30) Other
AT RISK (cotton & cotton blend)	1			Cards										
	2			Draw										
	3			Comb										
	4			Rove										
	5			Thru Out										
	6													
	7 (all)													
Control (synthetic & wool)	8													
Ex-Worker (cotton)	9													

Use actual wording of each question. Put X in appropriate square after each question. When in doubt record 'No'. When no square, circle appropriate answer.

B. COUGH

Do you usually cough first thing in the morning? (on getting up)† _____ Yes ___ No ___ (31)
(Count a cough with first smoke or on "first going out of doors." Exclude clearing throat or a single cough.)

Do you usually cough during the day or at night? _____ Yes ___ No ___ (32)
(Ignore an occasional cough.)

If 'Yes' to either question (31-32):

Do you cough like this on most days for as much as three months a year? _____ Yes ___ No ___ (33)

Do you cough on any particular day of the week? _____ Yes ___ No ___ (34)

(1) (2) (3) (4) (5) (6) (7)

If 'Yes': Which day? Mon. Tues. Wed. Thur. Fri. Sat Sun. (35)

C. PHLEGM or alternative word to suit local custom.

Do you usually bring up any phlegm from your chest first thing in the morning? (Count phlegm with the first smoke or on "first going out of doors." Exclude phlegm from the nose. Count swallowed phlegm.) (on getting up)† _____ Yes ___ No ___ (36)

Do you usually bring up any phlegm from your chest during the day or at night? (Accept twice or more.) _____ Yes ___ No ___ (37)

If 'Yes' to either question (36) or (37):

Do you bring up phlegm like this on most days for as much as three months each year? _____ Yes ___ No ___ (38)

If 'Yes' to question (33) or (39):

How long have you had this phlegm? (cough)
(Write in number of years

(1) ☐ 2 years or less
(2) ☐ More than 2 years-9 years
(3) ☐ 10-19 years
(4) ☐ 20+ years

†These words are for subjects who work at night

D. TIGHTNESS

Does your chest ever feel tight or your breathing become difficult? _____ Yes ___ No ___ (39)

Is your chest tight or your breathing difficult on any particular day of the week? (after a week or 10 days away from the mill) _____ Yes ___ No ___ (40)

If 'Yes': Which day? Mon. (1) Tues. (2) Wed. (3) Thur. (4) Fri. (5) Sat. (6) Sun. (7) (8) (41)
(1) Sometimes (2) Always

If 'Yes' Monday: At what time on Monday does your chest feel tight or your breathing difficult? 1 ☐ Before entering the mill 2 ☐ After entering the mill (42)

(Ask only if NO to Question (45)*

In the past, has your chest ever been tight or your breathing difficult on any particular day of the week? _____ Yes ___ No ___ (43)

If 'Yes': Which day? Mon. (1) Tues. (2) Wed. (3) Thur. (4) Fri. (5) Sat. (6) Sun. (7) (8) (44)
(1) Sometimes (2) Always

E. TOBACCO SMOKING*

*Have you changed your smoking habits since last interview? If yes specify what changes.

TABLE 1. PREDICTED FVC FOR MALES (KNUDSON, ET AL: AM REV RESPIR DIS. 1976. 113. 587.)

HT	AGE 17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
60.0	3.44	3.59	3.75	3.91	3.72	3.66	3.61	3.55	3.49	3.43	3.37	3.32	3.26	3.20	3.14	3.08	3.03	2.97	2.91	2.85	2.79	2.74	2.68	2.62	2.56
60.5	3.50	3.66	3.81	3.97	3.80	3.75	3.69	3.63	3.57	3.51	3.46	3.40	3.34	3.28	3.22	3.17	3.11	3.05	2.99	2.93	2.88	2.82	2.76	2.70	2.64
61.0	3.56	3.72	3.88	4.03	3.89	3.83	3.77	3.71	3.66	3.60	3.54	3.48	3.42	3.37	3.31	3.25	3.19	3.13	3.08	3.02	2.96	2.90	2.84	2.79	2.73
61.5	3.63	3.78	3.94	4.10	3.97	3.91	3.85	3.80	3.74	3.68	3.62	3.56	3.51	3.45	3.39	3.33	3.27	3.22	3.16	3.10	3.04	2.98	2.93	2.87	2.81
62.0	3.69	3.85	4.00	4.16	4.05	3.99	3.94	3.88	3.82	3.76	3.70	3.65	3.59	3.53	3.47	3.41	3.36	3.30	3.24	3.18	3.12	3.07	3.01	2.95	2.89
62.5	3.76	3.91	4.07	4.22	4.13	4.08	4.02	3.96	3.90	3.84	3.79	3.73	3.67	3.61	3.55	3.50	3.44	3.38	3.32	3.26	3.21	3.15	3.09	3.03	2.97
63.0	3.82	3.97	4.13	4.29	4.22	4.16	4.10	4.04	3.99	3.93	3.87	3.81	3.75	3.70	3.64	3.58	3.52	3.46	3.41	3.35	3.29	3.23	3.17	3.12	3.06
63.5	3.88	4.04	4.19	4.35	4.30	4.24	4.18	4.13	4.07	4.01	3.95	3.89	3.84	3.78	3.72	3.66	3.60	3.55	3.49	3.43	3.37	3.31	3.26	3.20	3.14
64.0	3.95	4.10	4.26	4.41	4.30	4.32	4.27	4.21	4.15	4.09	4.03	3.98	3.92	3.86	3.80	3.74	3.69	3.63	3.57	3.51	3.45	3.40	3.34	3.28	3.22
64.5	4.01	4.17	4.32	4.48	4.46	4.41	4.35	4.29	4.23	4.17	4.12	4.06	4.00	3.94	3.88	3.83	3.77	3.71	3.65	3.59	3.54	3.48	3.42	3.36	3.30
65.0	4.07	4.23	4.39	4.54	4.55	4.49	4.43	4.37	4.32	4.26	4.20	4.14	4.08	4.03	3.97	3.91	3.85	3.79	3.74	3.68	3.62	3.56	3.50	3.45	3.39
65.5	4.14	4.29	4.45	4.60	4.63	4.57	4.51	4.46	4.40	4.34	4.28	4.22	4.17	4.11	4.05	3.99	3.93	3.88	3.82	3.76	3.70	3.64	3.59	3.53	3.47
66.0	4.20	4.36	4.51	4.67	4.71	4.65	4.60	4.54	4.48	4.42	4.36	4.31	4.25	4.19	4.13	4.07	4.02	3.96	3.90	3.84	3.78	3.73	3.67	3.61	3.55
66.5	4.26	4.42	4.58	4.73	4.80	4.74	4.68	4.62	4.56	4.51	4.45	4.39	4.33	4.27	4.22	4.16	4.10	4.04	3.98	3.93	3.87	3.81	3.75	3.69	3.64
67.0	4.33	4.48	4.64	4.80	4.88	4.82	4.76	4.70	4.65	4.59	4.53	4.47	4.41	4.36	4.30	4.24	4.18	4.12	4.07	4.01	3.95	3.89	3.83	3.78	3.72
67.5	4.39	4.55	4.70	4.86	4.96	4.90	4.84	4.79	4.73	4.67	4.61	4.55	4.50	4.44	4.38	4.32	4.26	4.21	4.15	4.09	4.03	3.97	3.92	3.86	3.80
68.0	4.45	4.61	4.77	4.92	5.04	4.98	4.93	4.87	4.81	4.75	4.69	4.64	4.58	4.52	4.46	4.40	4.35	4.29	4.23	4.17	4.11	4.06	4.00	3.94	3.88
68.5	4.52	4.67	4.83	4.99	5.13	5.07	5.01	4.95	4.89	4.84	4.78	4.72	4.66	4.60	4.55	4.49	4.43	4.37	4.31	4.26	4.20	4.14	4.08	4.02	3.97
69.0	4.58	4.74	4.89	5.05	5.21	5.15	5.09	5.03	4.98	4.92	4.86	4.80	4.74	4.69	4.63	4.57	4.51	4.45	4.40	4.34	4.28	4.22	4.16	4.11	4.05
69.5	4.64	4.80	4.96	5.11	5.29	5.23	5.17	5.12	5.06	5.00	4.94	4.88	4.83	4.77	4.71	4.65	4.59	4.54	4.48	4.42	4.36	4.30	4.25	4.19	4.13
70.0	4.71	4.86	5.02	5.18	5.37	5.32	5.26	5.20	5.14	5.08	5.02	4.97	4.91	4.85	4.79	4.74	4.68	4.62	4.56	4.50	4.44	4.39	4.33	4.27	4.21
70.5	4.77	4.93	5.08	5.24	5.46	5.40	5.34	5.28	5.22	5.17	5.11	5.05	4.99	4.93	4.88	4.82	4.76	4.70	4.64	4.59	4.53	4.47	4.41	4.35	4.30
71.0	4.83	4.99	5.15	5.30	5.54	5.48	5.42	5.36	5.31	5.25	5.19	5.13	5.07	5.02	4.96	4.90	4.84	4.78	4.73	4.67	4.61	4.55	4.49	4.44	4.38
71.5	4.90	5.05	5.21	5.37	5.62	5.56	5.50	5.45	5.39	5.33	5.27	5.21	5.16	5.10	5.04	4.98	4.92	4.87	4.81	4.75	4.69	4.63	4.58	4.52	4.46
72.0	4.96	5.12	5.27	5.43	5.70	5.65	5.59	5.53	5.47	5.41	5.36	5.30	5.24	5.18	5.12	5.07	5.01	4.95	4.89	4.83	4.78	4.72	4.66	4.60	4.54
72.5	5.03	5.18	5.34	5.49	5.79	5.73	5.67	5.61	5.55	5.50	5.44	5.38	5.32	5.26	5.21	5.15	5.09	5.03	4.97	4.92	4.86	4.80	4.74	4.68	4.63
73.0	5.09	5.24	5.40	5.56	5.87	5.81	5.75	5.69	5.64	5.58	5.52	5.46	5.40	5.35	5.29	5.23	5.17	5.11	5.06	5.00	4.94	4.88	4.82	4.77	4.71
73.5	5.15	5.31	5.46	5.62	5.93	5.89	5.83	5.78	5.72	5.66	5.60	5.54	5.49	5.43	5.37	5.31	5.25	5.20	5.14	5.08	5.02	4.96	4.91	4.85	4.79
74.0	5.22	5.37	5.53	5.68	6.03	5.98	5.92	5.86	5.80	5.74	5.69	5.63	5.57	5.51	5.45	5.40	5.34	5.28	5.22	5.16	5.11	5.05	4.99	4.93	4.87
74.5	5.28	5.44	5.59	5.75	6.12	6.06	6.00	5.94	5.88	5.83	5.77	5.71	5.65	5.59	5.54	5.48	5.42	5.36	5.30	5.25	5.19	5.13	5.07	5.01	4.96
75.0	5.34	5.50	5.65	5.81	6.20	6.14	6.08	6.02	5.97	5.91	5.85	5.79	5.73	5.68	5.62	5.56	5.50	5.44	5.39	5.33	5.27	5.21	5.15	5.10	5.04
75.5	5.41	5.56	5.72	5.87	6.28	6.22	6.17	6.11	6.05	5.99	5.93	5.88	5.82	5.76	5.70	5.64	5.59	5.53	5.47	5.41	5.35	5.30	5.24	5.18	5.12
76.0	5.47	5.63	5.78	5.94	6.36	6.31	6.25	6.19	6.13	6.07	6.02	5.96	5.90	5.84	5.78	5.73	5.67	5.61	5.55	5.49	5.44	5.38	5.32	5.26	5.20
76.5	5.53	5.69	5.85	6.00	6.45	6.39	6.33	6.27	6.21	6.16	6.10	6.04	5.98	5.92	5.87	5.81	5.75	5.69	5.63	5.58	5.52	5.46	5.40	5.34	5.29
77.0	5.60	5.75	5.91	6.06	6.53	6.47	6.41	6.35	6.30	6.24	6.18	6.12	6.06	6.01	5.95	5.89	5.83	5.77	5.72	5.66	5.60	5.54	5.48	5.43	5.37
77.5	5.66	5.82	5.97	6.13	6.61	6.55	6.50	6.44	6.38	6.32	6.26	6.21	6.15	6.09	6.03	5.97	5.92	5.86	5.80	5.74	5.68	5.63	5.57	5.51	5.45
78.0	5.72	5.88	6.04	6.19	6.69	6.64	6.58	6.52	6.46	6.40	6.35	6.29	6.23	6.17	6.11	6.06	6.00	5.94	5.88	5.82	5.77	5.71	5.65	5.59	5.53
78.5	5.79	5.94	6.10	6.26	6.78	6.72	6.66	6.60	6.54	6.49	6.43	6.37	6.31	6.25	6.20	6.14	6.08	6.02	5.96	5.91	5.85	5.79	5.73	5.67	5.62
79.0	5.85	6.01	6.16	6.32	6.86	6.80	6.74	6.68	6.63	6.57	6.51	6.45	6.39	6.34	6.28	6.22	6.16	6.10	6.05	5.99	5.93	5.87	5.81	5.76	5.70
79.5	5.91	6.07	6.23	6.38	6.94	6.88	6.83	6.77	6.71	6.65	6.59	6.54	6.48	6.42	6.36	6.30	6.25	6.19	6.13	6.07	6.01	5.96	5.90	5.84	5.78
80.0	5.98	6.13	6.29	6.45	7.02	6.97	6.91	6.85	6.79	6.73	6.68	6.62	6.56	6.50	6.44	6.39	6.33	6.27	6.21	6.15	6.10	6.04	5.98	5.92	5.86
80.5	6.04	6.20	6.35	6.51	7.11	7.05	6.99	6.93	6.87	6.82	6.76	6.70	6.64	6.58	6.53	6.47	6.41	6.35	6.29	6.24	6.18	6.12	6.06	6.00	5.95
81.0	6.10	6.26	6.42	6.57	7.19	7.13	7.07	7.02	6.96	6.90	6.84	6.78	6.73	6.67	6.61	6.55	6.49	6.44	6.38	6.32	6.26	6.20	6.15	6.09	6.03
81.5	6.17	6.32	6.48	6.64	7.27	7.21	7.16	7.10	7.04	6.98	6.92	6.87	6.81	6.75	6.69	6.63	6.58	6.52	6.46	6.40	6.34	6.29	6.23	6.17	6.11
82.0	6.23	6.39	6.54	6.70	7.35	7.30	7.24	7.18	7.12	7.06	7.01	6.95	6.89	6.83	6.77	6.72	6.66	6.60	6.54	6.48	6.43	6.37	6.31	6.25	6.19
82.5	6.30	6.45	6.61	6.76	7.44	7.38	7.32	7.26	7.20	7.15	7.09	7.03	6.97	6.91	6.86	6.80	6.74	6.68	6.62	6.57	6.51	6.45	6.39	6.33	6.28
83.0	6.36	6.51	6.67	6.83	7.52	7.46	7.40	7.35	7.29	7.23	7.17	7.11	7.06	7.00	6.94	6.88	6.82	6.77	6.71	6.65	6.59	6.53	6.48	6.42	6.36
83.5	6.42	6.58	6.73	6.89	7.60	7.54	7.49	7.43	7.37	7.31	7.25	7.20	7.14	7.08	7.02	6.96	6.91	6.85	6.79	6.73	6.67	6.62	6.56	6.50	6.44
84.0	6.49	6.64	6.80	6.95	7.68	7.63	7.57	7.51	7.45	7.39	7.34	7.28	7.22	7.16	7.10	7.05	6.99	6.93	6.87	6.81	6.76	6.70	6.64	6.58	6.52
84.5	6.55	6.71	6.86	7.02	7.77	7.71	7.65	7.59	7.53	7.48	7.42	7.36	7.30	7.24	7.19	7.13	7.07	7.01	6.95	6.90	6.84	6.78	6.72	6.66	6.61
85.0	6.61	6.77	6.92	7.08	7.85	7.79	7.73	7.68	7.62	7.56	7.50	7.44	7.39	7.33	7.27	7.21	7.15	7.10	7.04	6.98	6.92	6.86	6.81	6.75	6.69

TABLE 2. PREDICTED FEV1 FOR MALES (KNUDSON, ET AL: AM REV RESPIR DIS. 1976. 113. 587.)

HT \ AGE	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
60.0	2.97	3.06	3.15	3.24	3.05	2.99	2.94	2.88	2.83	2.78	2.72	2.67	2.61	2.56	2.51	2.45	2.40	2.34	2.29	2.24	2.18	2.13	2.07	2.02	1.97
60.5	3.03	3.12	3.21	3.30	3.11	3.06	3.00	2.95	2.90	2.84	2.79	2.73	2.68	2.63	2.57	2.52	2.46	2.41	2.36	2.30	2.25	2.19	2.14	2.09	2.03
61.0	3.08	3.17	3.26	3.35	3.18	3.12	3.07	3.02	2.96	2.91	2.85	2.80	2.75	2.69	2.64	2.58	2.53	2.48	2.42	2.37	2.31	2.26	2.21	2.15	2.10
61.5	3.14	3.23	3.32	3.41	3.24	3.19	3.14	3.08	3.03	2.97	2.92	2.87	2.81	2.76	2.70	2.65	2.60	2.54	2.49	2.43	2.38	2.33	2.27	2.22	2.16
62.0	3.20	3.29	3.38	3.47	3.31	3.26	3.20	3.15	3.09	3.04	2.99	2.93	2.88	2.82	2.77	2.72	2.66	2.61	2.55	2.50	2.45	2.39	2.34	2.28	2.23
62.5	3.26	3.35	3.44	3.53	3.38	3.32	3.27	3.22	3.16	3.11	3.05	3.00	2.95	2.89	2.84	2.78	2.73	2.68	2.62	2.57	2.51	2.46	2.41	2.35	2.30
63.0	3.32	3.41	3.50	3.59	3.44	3.39	3.34	3.28	3.23	3.17	3.12	3.07	3.01	2.96	2.90	2.85	2.80	2.74	2.69	2.63	2.58	2.53	2.47	2.42	2.36
63.5	3.38	3.47	3.56	3.65	3.51	3.46	3.40	3.35	3.29	3.24	3.19	3.13	3.08	3.02	2.97	2.92	2.86	2.81	2.75	2.70	2.65	2.59	2.54	2.48	2.43
64.0	3.43	3.52	3.61	3.70	3.58	3.52	3.47	3.41	3.36	3.31	3.25	3.20	3.14	3.09	3.04	2.98	2.93	2.87	2.82	2.77	2.71	2.66	2.60	2.55	2.50
64.5	3.49	3.58	3.67	3.76	3.64	3.59	3.53	3.48	3.43	3.37	3.32	3.26	3.21	3.16	3.10	3.05	2.99	2.94	2.89	2.83	2.78	2.72	2.67	2.62	2.56
65.0	3.55	3.64	3.73	3.82	3.71	3.65	3.60	3.55	3.49	3.44	3.38	3.33	3.28	3.22	3.17	3.11	3.06	3.01	2.95	2.90	2.84	2.79	2.74	2.68	2.63
65.5	3.61	3.70	3.79	3.88	3.77	3.72	3.67	3.61	3.56	3.50	3.45	3.40	3.34	3.29	3.23	3.18	3.13	3.07	3.02	2.96	2.91	2.86	2.80	2.75	2.69
66.0	3.67	3.76	3.85	3.94	3.84	3.79	3.73	3.68	3.62	3.57	3.52	3.46	3.41	3.35	3.30	3.25	3.19	3.14	3.08	3.03	2.98	2.92	2.87	2.81	2.76
66.5	3.73	3.82	3.91	4.00	3.91	3.85	3.80	3.74	3.69	3.64	3.58	3.53	3.47	3.42	3.37	3.31	3.26	3.20	3.15	3.10	3.04	2.99	2.93	2.88	2.83
67.0	3.79	3.88	3.97	4.06	3.97	3.92	3.86	3.81	3.76	3.70	3.65	3.59	3.54	3.49	3.43	3.38	3.32	3.27	3.22	3.16	3.11	3.05	3.00	2.95	2.89
67.5	3.84	3.93	4.02	4.11	4.04	3.98	3.93	3.88	3.82	3.77	3.71	3.66	3.61	3.55	3.50	3.44	3.39	3.34	3.28	3.23	3.17	3.12	3.07	3.01	2.96
68.0	3.90	3.99	4.08	4.17	4.10	4.05	4.00	3.94	3.89	3.83	3.78	3.73	3.67	3.62	3.56	3.51	3.46	3.40	3.35	3.29	3.24	3.19	3.13	3.08	3.02
68.5	3.96	4.05	4.14	4.23	4.17	4.12	4.06	4.01	3.95	3.90	3.85	3.79	3.74	3.68	3.63	3.58	3.52	3.47	3.41	3.36	3.31	3.25	3.20	3.14	3.09
69.0	4.02	4.11	4.20	4.29	4.24	4.18	4.13	4.07	4.02	3.97	3.91	3.86	3.80	3.75	3.70	3.64	3.59	3.53	3.48	3.43	3.37	3.32	3.26	3.21	3.16
69.5	4.08	4.17	4.26	4.35	4.30	4.25	4.19	4.14	4.09	4.03	3.98	3.92	3.87	3.82	3.76	3.71	3.65	3.60	3.55	3.49	3.44	3.38	3.33	3.28	3.22
70.0	4.14	4.23	4.32	4.41	4.37	4.31	4.26	4.21	4.15	4.10	4.04	3.99	3.94	3.88	3.83	3.77	3.72	3.67	3.61	3.56	3.50	3.45	3.40	3.34	3.29
70.5	4.19	4.28	4.37	4.46	4.43	4.38	4.33	4.27	4.22	4.16	4.11	4.06	4.00	3.95	3.89	3.84	3.79	3.73	3.68	3.62	3.57	3.52	3.46	3.41	3.35
71.0	4.25	4.34	4.43	4.52	4.50	4.45	4.39	4.34	4.28	4.23	4.18	4.12	4.07	4.01	3.96	3.91	3.85	3.80	3.74	3.69	3.64	3.58	3.53	3.47	3.42
71.5	4.31	4.40	4.49	4.58	4.57	4.51	4.46	4.40	4.35	4.30	4.24	4.19	4.13	4.08	4.03	3.97	3.92	3.86	3.81	3.76	3.70	3.65	3.59	3.54	3.49
72.0	4.37	4.46	4.55	4.64	4.63	4.58	4.52	4.47	4.42	4.36	4.31	4.25	4.20	4.15	4.09	4.04	3.98	3.93	3.88	3.82	3.77	3.71	3.66	3.61	3.55
72.5	4.43	4.52	4.61	4.70	4.70	4.64	4.59	4.54	4.48	4.43	4.37	4.32	4.27	4.21	4.16	4.10	4.05	4.00	3.94	3.89	3.83	3.78	3.73	3.67	3.62
73.0	4.49	4.58	4.67	4.76	4.76	4.71	4.66	4.60	4.55	4.49	4.44	4.39	4.33	4.28	4.22	4.17	4.12	4.06	4.01	3.95	3.90	3.85	3.79	3.74	3.68
73.5	4.54	4.63	4.72	4.81	4.83	4.78	4.72	4.67	4.61	4.56	4.51	4.45	4.40	4.34	4.29	4.24	4.18	4.13	4.07	4.02	3.97	3.91	3.86	3.80	3.75
74.0	4.60	4.69	4.78	4.87	4.90	4.84	4.79	4.73	4.68	4.63	4.57	4.52	4.46	4.41	4.36	4.30	4.25	4.19	4.14	4.09	4.03	3.98	3.92	3.87	3.82
74.5	4.66	4.75	4.84	4.93	4.96	4.91	4.85	4.80	4.75	4.69	4.64	4.58	4.53	4.48	4.42	4.37	4.31	4.26	4.21	4.15	4.10	4.04	3.99	3.94	3.88
75.0	4.72	4.81	4.90	4.99	5.03	4.97	4.92	4.87	4.81	4.76	4.70	4.65	4.60	4.54	4.49	4.43	4.38	4.33	4.27	4.22	4.16	4.11	4.06	4.00	3.95
75.5	4.78	4.87	4.96	5.05	5.09	5.04	4.99	4.93	4.88	4.82	4.77	4.72	4.66	4.61	4.55	4.50	4.45	4.39	4.34	4.28	4.23	4.18	4.12	4.07	4.01
76.0	4.84	4.93	5.02	5.11	5.16	5.11	5.05	5.00	4.94	4.89	4.84	4.78	4.73	4.67	4.62	4.57	4.51	4.46	4.40	4.35	4.30	4.24	4.19	4.13	4.08
76.5	4.90	4.99	5.08	5.17	5.23	5.17	5.12	5.06	5.01	4.96	4.90	4.85	4.79	4.74	4.69	4.63	4.58	4.52	4.47	4.42	4.36	4.31	4.25	4.20	4.15
77.0	4.95	5.04	5.13	5.22	5.29	5.24	5.18	5.13	5.08	5.02	4.97	4.91	4.86	4.81	4.75	4.70	4.64	4.59	4.54	4.48	4.43	4.37	4.32	4.27	4.21
77.5	5.01	5.10	5.19	5.28	5.36	5.30	5.25	5.20	5.14	5.09	5.03	4.98	4.93	4.87	4.82	4.76	4.71	4.66	4.60	4.55	4.49	4.44	4.39	4.33	4.28
78.0	5.07	5.16	5.25	5.34	5.42	5.37	5.32	5.26	5.21	5.15	5.10	5.05	4.99	4.94	4.88	4.83	4.78	4.72	4.67	4.61	4.56	4.51	4.45	4.40	4.34
78.5	5.13	5.22	5.31	5.40	5.49	5.44	5.38	5.33	5.27	5.22	5.17	5.11	5.06	5.00	4.95	4.90	4.84	4.79	4.73	4.68	4.63	4.57	4.52	4.46	4.41
79.0	5.19	5.28	5.37	5.46	5.56	5.50	5.45	5.39	5.34	5.29	5.23	5.18	5.12	5.07	5.02	4.96	4.91	4.85	4.80	4.75	4.69	4.64	4.58	4.53	4.48
79.5	5.25	5.34	5.43	5.52	5.62	5.57	5.51	5.46	5.41	5.35	5.30	5.24	5.19	5.14	5.08	5.03	4.97	4.92	4.87	4.81	4.76	4.70	4.65	4.60	4.54
80.0	5.30	5.39	5.48	5.57	5.69	5.63	5.58	5.53	5.47	5.42	5.36	5.31	5.26	5.20	5.15	5.09	5.04	4.99	4.93	4.88	4.82	4.77	4.72	4.66	4.61
80.5	5.36	5.45	5.54	5.63	5.75	5.70	5.65	5.59	5.54	5.48	5.43	5.38	5.32	5.27	5.21	5.16	5.11	5.05	5.00	4.94	4.89	4.84	4.78	4.73	4.67
81.0	5.42	5.51	5.60	5.69	5.82	5.77	5.71	5.66	5.60	5.55	5.50	5.44	5.39	5.33	5.28	5.23	5.17	5.12	5.06	5.01	4.96	4.90	4.85	4.79	4.74
81.5	5.48	5.57	5.66	5.75	5.89	5.83	5.78	5.72	5.67	5.62	5.56	5.51	5.45	5.40	5.35	5.29	5.24	5.18	5.13	5.08	5.02	4.97	4.91	4.86	4.81
82.0	5.54	5.63	5.72	5.81	5.95	5.90	5.84	5.79	5.74	5.68	5.63	5.57	5.52	5.47	5.41	5.36	5.30	5.25	5.20	5.14	5.09	5.03	4.98	4.93	4.87
82.5	5.60	5.69	5.78	5.87	6.02	5.96	5.91	5.86	5.80	5.75	5.69	5.64	5.59	5.53	5.48	5.42	5.37	5.32	5.26	5.21	5.15	5.10	5.05	4.99	4.94
83.0	5.65	5.74	5.83	5.92	6.08	6.03	5.98	5.92	5.87	5.81	5.76	5.71	5.65	5.60	5.54	5.49	5.44	5.38	5.33	5.27	5.22	5.17	5.11	5.06	5.00
83.5	5.71	5.80	5.89	5.98	6.15	6.10	6.04	5.99	5.93	5.88	5.83	5.77	5.72	5.66	5.61	5.56	5.50	5.45	5.39	5.34	5.29	5.23	5.18	5.12	5.07
84.0	5.77	5.86	5.95	6.04	6.22	6.16	6.11	6.05	6.00	5.95	5.89	5.84	5.78	5.73	5.68	5.62	5.57	5.51	5.46	5.41	5.35	5.30	5.24	5.19	5.14
84.5	5.83	5.92	6.01	6.10	6.28	6.23	6.17	6.12	6.07	6.01	5.96	5.90	5.85	5.80	5.74	5.69	5.63	5.58	5.53	5.47	5.42	5.36	5.31	5.26	5.20
85.0	5.89	5.98	6.07	6.16	6.35	6.29	6.24	6.19	6.13	6.08	6.02	5.97	5.92	5.86	5.81	5.75	5.70	5.65	5.59	5.54	5.48	5.43	5.38	5.32	5.27

TABLE 3. PREDICTED FVC FOR FEMALES (HUDSON, ET AL: AM REV RESPIR DIS. 1976. 113. 587.)

HT	AGE 17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
52.0	2.45	2.64	2.65	2.61	2.56	2.52	2.47	2.43	2.39	2.34	2.30	2.25	2.21	2.17	2.12	2.08	2.03	1.99	1.95	1.90	1.86	1.81	1.77	1.73	1.68
52.5	2.50	2.68	2.70	2.65	2.61	2.57	2.52	2.48	2.43	2.39	2.35	2.30	2.26	2.21	2.17	2.13	2.08	2.04	1.99	1.95	1.91	1.86	1.82	1.77	1.73
53.0	2.54	2.72	2.74	2.70	2.66	2.61	2.57	2.52	2.48	2.44	2.39	2.35	2.30	2.26	2.22	2.17	2.13	2.08	2.04	2.00	1.95	1.91	1.86	1.82	1.78
53.5	2.58	2.76	2.79	2.75	2.70	2.66	2.62	2.57	2.53	2.48	2.44	2.40	2.35	2.31	2.26	2.22	2.18	2.13	2.09	2.04	2.00	1.96	1.91	1.87	1.82
54.0	2.62	2.81	2.84	2.79	2.75	2.71	2.66	2.62	2.57	2.53	2.49	2.44	2.40	2.35	2.31	2.27	2.22	2.18	2.13	2.09	2.05	2.00	1.96	1.91	1.87
54.5	2.66	2.85	2.89	2.84	2.80	2.75	2.71	2.67	2.62	2.58	2.53	2.49	2.45	2.40	2.36	2.31	2.27	2.23	2.18	2.14	2.09	2.05	2.01	1.96	1.92
55.0	2.71	2.89	2.93	2.89	2.84	2.80	2.76	2.71	2.67	2.62	2.58	2.54	2.49	2.45	2.40	2.36	2.32	2.27	2.23	2.18	2.14	2.10	2.05	2.01	1.96
55.5	2.75	2.93	2.98	2.94	2.89	2.85	2.80	2.76	2.72	2.67	2.63	2.58	2.54	2.50	2.45	2.41	2.36	2.32	2.28	2.23	2.19	2.14	2.10	2.06	2.01
56.0	2.79	2.97	3.03	2.98	2.94	2.89	2.85	2.81	2.76	2.72	2.67	2.63	2.59	2.54	2.50	2.45	2.41	2.37	2.32	2.28	2.23	2.19	2.15	2.10	2.06
56.5	2.83	3.01	3.07	3.03	2.99	2.94	2.90	2.85	2.81	2.77	2.72	2.68	2.63	2.59	2.55	2.50	2.46	2.41	2.37	2.33	2.28	2.24	2.19	2.15	2.11
57.0	2.87	3.06	3.12	3.08	3.03	2.99	2.94	2.90	2.86	2.81	2.77	2.72	2.68	2.64	2.59	2.55	2.50	2.46	2.42	2.37	2.33	2.28	2.24	2.20	2.15
57.5	2.91	3.10	3.17	3.12	3.08	3.04	2.99	2.95	2.90	2.86	2.82	2.77	2.73	2.68	2.64	2.60	2.55	2.51	2.46	2.42	2.38	2.33	2.29	2.24	2.20
58.0	2.96	3.14	3.21	3.17	3.13	3.08	3.04	2.99	2.95	2.91	2.86	2.82	2.77	2.73	2.69	2.64	2.60	2.55	2.51	2.47	2.42	2.38	2.33	2.29	2.25
58.5	3.00	3.18	3.26	3.22	3.17	3.13	3.09	3.04	3.00	2.95	2.91	2.87	2.82	2.78	2.73	2.69	2.65	2.60	2.56	2.51	2.47	2.43	2.38	2.34	2.29
59.0	3.04	3.22	3.31	3.26	3.22	3.18	3.13	3.09	3.04	3.00	2.96	2.91	2.87	2.82	2.78	2.74	2.69	2.65	2.60	2.56	2.52	2.47	2.43	2.38	2.34
59.5	3.08	3.27	3.36	3.31	3.27	3.22	3.18	3.14	3.09	3.05	3.00	2.96	2.92	2.87	2.83	2.78	2.74	2.70	2.65	2.61	2.56	2.52	2.48	2.43	2.39
60.0	3.12	3.31	3.40	3.36	3.31	3.27	3.23	3.18	3.14	3.09	3.05	3.01	2.96	2.92	2.87	2.83	2.79	2.74	2.70	2.65	2.61	2.57	2.52	2.48	2.43
60.5	3.17	3.35	3.45	3.41	3.36	3.32	3.27	3.23	3.19	3.14	3.10	3.05	3.01	2.97	2.92	2.88	2.83	2.79	2.75	2.70	2.66	2.61	2.57	2.53	2.48
61.0	3.21	3.39	3.50	3.45	3.41	3.36	3.32	3.28	3.23	3.19	3.14	3.10	3.06	3.01	2.97	2.92	2.88	2.84	2.79	2.75	2.70	2.66	2.62	2.57	2.53
61.5	3.25	3.43	3.54	3.50	3.46	3.41	3.37	3.32	3.28	3.24	3.19	3.15	3.10	3.06	3.02	2.97	2.93	2.88	2.84	2.80	2.75	2.71	2.66	2.62	2.58
62.0	3.29	3.48	3.59	3.55	3.50	3.46	3.41	3.37	3.33	3.28	3.24	3.19	3.15	3.11	3.06	3.02	2.97	2.93	2.89	2.84	2.80	2.75	2.71	2.67	2.62
62.5	3.33	3.52	3.64	3.59	3.55	3.51	3.46	3.42	3.37	3.33	3.29	3.24	3.20	3.15	3.11	3.07	3.02	2.98	2.93	2.89	2.85	2.80	2.76	2.71	2.67
63.0	3.38	3.56	3.68	3.64	3.60	3.55	3.51	3.46	3.42	3.38	3.33	3.29	3.24	3.20	3.16	3.11	3.07	3.02	2.98	2.94	2.89	2.85	2.80	2.76	2.72
63.5	3.42	3.60	3.73	3.69	3.64	3.60	3.56	3.51	3.47	3.42	3.38	3.34	3.29	3.25	3.20	3.16	3.12	3.07	3.03	2.98	2.94	2.90	2.85	2.81	2.76
64.0	3.46	3.64	3.78	3.73	3.69	3.65	3.60	3.56	3.51	3.47	3.43	3.38	3.34	3.29	3.25	3.21	3.16	3.12	3.07	3.03	2.99	2.94	2.90	2.85	2.81
64.5	3.50	3.69	3.83	3.78	3.74	3.69	3.65	3.61	3.56	3.52	3.47	3.43	3.39	3.34	3.30	3.25	3.21	3.17	3.12	3.08	3.03	2.99	2.95	2.90	2.86
65.0	3.54	3.73	3.87	3.83	3.78	3.74	3.70	3.65	3.61	3.56	3.52	3.48	3.43	3.39	3.34	3.30	3.26	3.21	3.17	3.12	3.08	3.04	2.99	2.95	2.90
65.5	3.59	3.77	3.92	3.88	3.83	3.79	3.74	3.70	3.66	3.61	3.57	3.52	3.48	3.44	3.39	3.35	3.30	3.26	3.22	3.17	3.13	3.08	3.04	3.00	2.95
66.0	3.63	3.81	3.97	3.92	3.88	3.83	3.79	3.75	3.70	3.66	3.61	3.57	3.53	3.48	3.44	3.39	3.35	3.31	3.26	3.22	3.17	3.13	3.09	3.04	3.00
66.5	3.67	3.85	4.01	3.97	3.93	3.88	3.84	3.79	3.75	3.71	3.66	3.62	3.57	3.53	3.49	3.44	3.40	3.35	3.31	3.27	3.22	3.18	3.13	3.09	3.05
67.0	3.71	3.89	4.06	4.02	3.97	3.93	3.88	3.84	3.80	3.75	3.71	3.66	3.62	3.58	3.53	3.49	3.44	3.40	3.36	3.31	3.27	3.22	3.18	3.14	3.09
67.5	3.75	3.94	4.11	4.06	4.02	3.98	3.93	3.89	3.84	3.80	3.76	3.71	3.67	3.62	3.58	3.54	3.49	3.45	3.40	3.36	3.32	3.27	3.23	3.18	3.14
68.0	3.79	3.98	4.15	4.11	4.07	4.02	3.98	3.93	3.89	3.85	3.80	3.76	3.71	3.67	3.63	3.58	3.54	3.49	3.45	3.41	3.36	3.32	3.27	3.23	3.19
68.5	3.84	4.02	4.20	4.16	4.11	4.07	4.03	3.98	3.94	3.89	3.85	3.81	3.76	3.72	3.67	3.63	3.59	3.54	3.50	3.45	3.41	3.37	3.32	3.28	3.23
69.0	3.88	4.06	4.25	4.20	4.16	4.12	4.07	4.03	3.98	3.94	3.90	3.85	3.81	3.76	3.72	3.68	3.63	3.59	3.54	3.50	3.46	3.41	3.37	3.32	3.28
69.5	3.92	4.10	4.30	4.25	4.21	4.16	4.12	4.08	4.03	3.99	3.94	3.90	3.86	3.81	3.77	3.72	3.68	3.64	3.59	3.55	3.50	3.46	3.42	3.37	3.33
70.0	3.96	4.15	4.34	4.30	4.25	4.21	4.17	4.12	4.08	4.03	3.99	3.95	3.90	3.86	3.81	3.77	3.73	3.68	3.64	3.59	3.55	3.51	3.46	3.42	3.37
70.5	4.00	4.19	4.39	4.35	4.30	4.26	4.21	4.17	4.13	4.08	4.04	3.99	3.95	3.91	3.86	3.82	3.77	3.73	3.69	3.64	3.60	3.55	3.51	3.47	3.42
71.0	4.05	4.23	4.44	4.39	4.35	4.30	4.26	4.22	4.17	4.13	4.08	4.04	4.00	3.95	3.91	3.86	3.82	3.78	3.73	3.69	3.64	3.60	3.56	3.51	3.47
71.5	4.09	4.27	4.48	4.44	4.40	4.35	4.31	4.26	4.22	4.18	4.13	4.09	4.04	4.00	3.96	3.91	3.87	3.82	3.78	3.74	3.69	3.65	3.60	3.56	3.52
72.0	4.13	4.31	4.53	4.49	4.44	4.40	4.35	4.31	4.27	4.22	4.18	4.13	4.09	4.05	4.00	3.96	3.91	3.87	3.83	3.78	3.74	3.69	3.65	3.61	3.56
72.5	4.17	4.36	4.58	4.53	4.49	4.45	4.40	4.36	4.31	4.27	4.23	4.18	4.14	4.09	4.05	4.01	3.96	3.92	3.87	3.83	3.79	3.74	3.70	3.65	3.61
73.0	4.21	4.40	4.62	4.58	4.54	4.49	4.45	4.40	4.36	4.32	4.27	4.23	4.18	4.14	4.10	4.05	4.01	3.96	3.92	3.88	3.83	3.79	3.74	3.70	3.66
73.5	4.26	4.44	4.67	4.63	4.58	4.54	4.50	4.45	4.41	4.36	4.32	4.28	4.23	4.19	4.14	4.10	4.06	4.01	3.97	3.92	3.88	3.84	3.79	3.75	3.70
74.0	4.30	4.48	4.72	4.67	4.63	4.59	4.54	4.50	4.45	4.41	4.37	4.32	4.28	4.23	4.19	4.15	4.10	4.06	4.01	3.97	3.93	3.88	3.84	3.79	3.75
74.5	4.34	4.52	4.77	4.72	4.68	4.63	4.59	4.55	4.50	4.46	4.41	4.37	4.33	4.28	4.24	4.19	4.15	4.11	4.06	4.02	3.97	3.93	3.89	3.84	3.80
75.0	4.38	4.57	4.81	4.77	4.72	4.68	4.64	4.59	4.55	4.50	4.46	4.42	4.37	4.33	4.28	4.24	4.20	4.15	4.11	4.06	4.02	3.98	3.93	3.89	3.84
75.5	4.42	4.61	4.86	4.82	4.77	4.73	4.68	4.64	4.60	4.55	4.51	4.46	4.42	4.38	4.33	4.29	4.24	4.20	4.16	4.11	4.07	4.02	3.98	3.94	3.89
76.0	4.47	4.65	4.91	4.86	4.82	4.77	4.73	4.69	4.64	4.60	4.55	4.51	4.47	4.42	4.38	4.33	4.29	4.25	4.20	4.16	4.11	4.07	4.03	3.98	3.94
76.5	4.51	4.69	4.95	4.91	4.87	4.82	4.78	4.73	4.69	4.65	4.60	4.56	4.51	4.47	4.43	4.38	4.34	4.29	4.25	4.21	4.16	4.12	4.07	4.03	3.99
77.0	4.55	4.73	5.00	4.96	4.91	4.87	4.82	4.78	4.74	4.69	4.65	4.60	4.56	4.52	4.47	4.43	4.38	4.34	4.30	4.25	4.21	4.16	4.12	4.08	4.03

TABLE 4. PREDICTED FEV1 FOR FEMALES (KNUDSON, ET AL: AM REV RESPIR DIS. 1976. 113. 587.)

HT \ AGE	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
52.0	2.31	2.48	2.33	2.29	2.25	2.21	2.16	2.12	2.08	2.04	2.00	1.95	1.91	1.87	1.83	1.79	1.74	1.70	1.66	1.62	1.58	1.53	1.49	1.45	1.41
52.5	2.34	2.51	2.37	2.32	2.28	2.24	2.20	2.16	2.11	2.07	2.03	1.99	1.95	1.90	1.86	1.82	1.78	1.74	1.69	1.65	1.61	1.57	1.53	1.48	1.44
53.0	2.38	2.55	2.40	2.36	2.32	2.27	2.23	2.19	2.15	2.11	2.06	2.02	1.98	1.94	1.90	1.85	1.81	1.77	1.73	1.69	1.64	1.60	1.56	1.52	1.48
53.5	2.41	2.58	2.43	2.39	2.35	2.31	2.27	2.22	2.18	2.14	2.10	2.06	2.01	1.97	1.93	1.89	1.85	1.80	1.76	1.72	1.68	1.64	1.59	1.55	1.51
54.0	2.45	2.62	2.47	2.43	2.38	2.34	2.30	2.26	2.22	2.17	2.13	2.09	2.05	2.01	1.96	1.92	1.88	1.84	1.80	1.75	1.71	1.67	1.63	1.59	1.54
54.5	2.48	2.65	2.50	2.46	2.42	2.38	2.33	2.29	2.25	2.21	2.17	2.12	2.08	2.04	2.00	1.96	1.91	1.87	1.83	1.79	1.75	1.70	1.66	1.62	1.58
55.0	2.51	2.68	2.54	2.49	2.45	2.41	2.37	2.33	2.28	2.24	2.20	2.16	2.12	2.07	2.03	1.99	1.95	1.91	1.86	1.82	1.78	1.74	1.70	1.65	1.61
55.5	2.55	2.72	2.57	2.53	2.49	2.45	2.40	2.36	2.32	2.28	2.24	2.19	2.15	2.11	2.07	2.03	1.98	1.94	1.90	1.86	1.82	1.77	1.73	1.69	1.65
56.0	2.58	2.75	2.61	2.56	2.52	2.48	2.44	2.40	2.35	2.31	2.27	2.23	2.19	2.14	2.10	2.06	2.02	1.98	1.93	1.89	1.85	1.81	1.77	1.72	1.68
56.5	2.62	2.79	2.64	2.60	2.56	2.51	2.47	2.43	2.39	2.35	2.30	2.26	2.22	2.18	2.14	2.09	2.05	2.01	1.97	1.93	1.88	1.84	1.80	1.76	1.72
57.0	2.65	2.82	2.67	2.63	2.59	2.55	2.51	2.46	2.42	2.38	2.34	2.30	2.25	2.21	2.17	2.13	2.09	2.04	2.00	1.96	1.92	1.88	1.83	1.79	1.75
57.5	2.69	2.86	2.71	2.67	2.62	2.58	2.54	2.50	2.46	2.41	2.37	2.33	2.29	2.25	2.20	2.16	2.12	2.08	2.04	1.99	1.95	1.91	1.87	1.83	1.78
58.0	2.72	2.89	2.74	2.70	2.66	2.62	2.57	2.53	2.49	2.45	2.41	2.36	2.32	2.28	2.24	2.20	2.15	2.11	2.07	2.03	1.99	1.94	1.90	1.86	1.82
58.5	2.75	2.92	2.78	2.73	2.69	2.65	2.61	2.57	2.52	2.48	2.44	2.40	2.36	2.31	2.27	2.23	2.19	2.15	2.10	2.06	2.02	1.98	1.94	1.89	1.85
59.0	2.79	2.96	2.81	2.77	2.73	2.69	2.64	2.60	2.56	2.52	2.48	2.43	2.39	2.35	2.31	2.27	2.22	2.18	2.14	2.10	2.06	2.01	1.97	1.93	1.89
59.5	2.82	2.99	2.85	2.80	2.76	2.72	2.68	2.64	2.59	2.55	2.51	2.47	2.43	2.38	2.34	2.30	2.26	2.22	2.17	2.13	2.09	2.05	2.01	1.96	1.92
60.0	2.86	3.03	2.88	2.84	2.80	2.75	2.71	2.67	2.63	2.59	2.54	2.50	2.46	2.42	2.38	2.33	2.29	2.25	2.21	2.17	2.12	2.08	2.04	2.00	1.96
60.5	2.89	3.06	2.91	2.87	2.83	2.79	2.75	2.70	2.66	2.62	2.58	2.54	2.49	2.45	2.41	2.37	2.33	2.28	2.24	2.20	2.16	2.12	2.07	2.03	1.99
61.0	2.93	3.10	2.95	2.91	2.86	2.82	2.78	2.74	2.70	2.65	2.61	2.57	2.53	2.49	2.44	2.40	2.36	2.32	2.28	2.23	2.19	2.15	2.11	2.07	2.02
61.5	2.96	3.13	2.98	2.94	2.90	2.86	2.81	2.77	2.73	2.69	2.65	2.60	2.56	2.52	2.48	2.44	2.39	2.35	2.31	2.27	2.23	2.18	2.14	2.10	2.06
62.0	2.99	3.16	3.02	2.97	2.93	2.89	2.85	2.81	2.76	2.72	2.68	2.64	2.60	2.55	2.51	2.47	2.43	2.39	2.34	2.30	2.26	2.22	2.18	2.13	2.09
62.5	3.03	3.20	3.05	3.01	2.97	2.93	2.88	2.84	2.80	2.76	2.72	2.67	2.63	2.59	2.55	2.51	2.46	2.42	2.38	2.34	2.30	2.25	2.21	2.17	2.13
63.0	3.06	3.23	3.09	3.04	3.00	2.96	2.92	2.88	2.83	2.79	2.75	2.71	2.67	2.62	2.58	2.54	2.50	2.46	2.41	2.37	2.33	2.29	2.25	2.20	2.16
63.5	3.10	3.27	3.12	3.08	3.04	2.99	2.95	2.91	2.87	2.83	2.78	2.74	2.70	2.66	2.62	2.57	2.53	2.49	2.45	2.41	2.36	2.32	2.28	2.24	2.20
64.0	3.13	3.30	3.15	3.11	3.07	3.03	2.99	2.94	2.90	2.86	2.82	2.78	2.73	2.69	2.65	2.61	2.57	2.52	2.48	2.44	2.40	2.36	2.31	2.27	2.23
64.5	3.17	3.34	3.19	3.15	3.10	3.06	3.02	2.98	2.94	2.89	2.85	2.81	2.77	2.73	2.68	2.64	2.60	2.56	2.52	2.47	2.43	2.39	2.35	2.31	2.26
65.0	3.20	3.37	3.22	3.18	3.14	3.10	3.05	3.01	2.97	2.93	2.89	2.84	2.80	2.76	2.72	2.68	2.63	2.59	2.55	2.51	2.47	2.42	2.38	2.34	2.30
65.5	3.23	3.40	3.26	3.21	3.17	3.13	3.09	3.05	3.00	2.96	2.92	2.88	2.84	2.79	2.75	2.71	2.67	2.63	2.58	2.54	2.50	2.46	2.42	2.37	2.33
66.0	3.27	3.44	3.29	3.25	3.21	3.17	3.12	3.08	3.04	3.00	2.96	2.91	2.87	2.83	2.79	2.75	2.70	2.66	2.62	2.58	2.54	2.49	2.45	2.41	2.37
66.5	3.30	3.47	3.33	3.28	3.24	3.20	3.16	3.12	3.07	3.03	2.99	2.95	2.91	2.86	2.82	2.78	2.74	2.70	2.65	2.61	2.57	2.53	2.49	2.44	2.40
67.0	3.34	3.51	3.36	3.32	3.28	3.23	3.19	3.15	3.11	3.07	3.02	2.98	2.94	2.90	2.86	2.81	2.77	2.73	2.69	2.65	2.60	2.56	2.52	2.48	2.44
67.5	3.37	3.54	3.39	3.35	3.31	3.27	3.23	3.18	3.14	3.10	3.06	3.02	2.97	2.93	2.89	2.85	2.81	2.76	2.72	2.68	2.64	2.60	2.55	2.51	2.47
68.0	3.41	3.58	3.43	3.39	3.34	3.30	3.26	3.22	3.18	3.13	3.09	3.05	3.01	2.97	2.92	2.88	2.84	2.80	2.76	2.71	2.67	2.63	2.59	2.55	2.50
68.5	3.44	3.61	3.46	3.42	3.38	3.34	3.29	3.25	3.21	3.17	3.13	3.08	3.04	3.00	2.96	2.92	2.87	2.83	2.79	2.75	2.71	2.66	2.62	2.58	2.54
69.0	3.47	3.64	3.50	3.46	3.41	3.37	3.33	3.29	3.25	3.20	3.16	3.12	3.08	3.04	2.99	2.95	2.91	2.87	2.83	2.78	2.74	2.70	2.66	2.62	2.57
69.5	3.51	3.68	3.53	3.49	3.45	3.41	3.36	3.32	3.28	3.24	3.20	3.15	3.11	3.07	3.03	2.99	2.94	2.90	2.86	2.82	2.78	2.73	2.69	2.65	2.61
70.0	3.54	3.71	3.57	3.52	3.48	3.44	3.40	3.36	3.31	3.27	3.23	3.19	3.15	3.10	3.06	3.02	2.98	2.94	2.89	2.85	2.81	2.77	2.73	2.68	2.64
70.5	3.58	3.75	3.60	3.56	3.52	3.47	3.43	3.39	3.35	3.31	3.26	3.22	3.18	3.14	3.10	3.05	3.01	2.97	2.93	2.89	2.84	2.80	2.76	2.72	2.68
71.0	3.61	3.78	3.63	3.59	3.55	3.51	3.47	3.42	3.38	3.34	3.30	3.26	3.21	3.17	3.13	3.09	3.05	3.00	2.96	2.92	2.88	2.84	2.79	2.75	2.71
71.5	3.65	3.82	3.67	3.63	3.58	3.54	3.50	3.46	3.42	3.37	3.33	3.29	3.25	3.21	3.16	3.12	3.08	3.04	3.00	2.95	2.91	2.87	2.83	2.79	2.74
72.0	3.68	3.85	3.70	3.66	3.62	3.58	3.53	3.49	3.45	3.41	3.37	3.32	3.28	3.24	3.20	3.16	3.11	3.07	3.03	2.99	2.95	2.90	2.86	2.82	2.78
72.5	3.71	3.88	3.74	3.70	3.65	3.61	3.57	3.53	3.49	3.44	3.40	3.36	3.32	3.28	3.23	3.19	3.15	3.11	3.07	3.02	2.98	2.94	2.90	2.86	2.81
73.0	3.75	3.92	3.77	3.73	3.69	3.65	3.60	3.56	3.52	3.48	3.44	3.39	3.35	3.31	3.27	3.23	3.18	3.14	3.10	3.06	3.02	2.97	2.93	2.89	2.85
73.5	3.78	3.95	3.81	3.76	3.72	3.68	3.64	3.60	3.55	3.51	3.47	3.43	3.39	3.34	3.30	3.26	3.22	3.18	3.13	3.09	3.05	3.01	2.97	2.92	2.88
74.0	3.82	3.99	3.84	3.80	3.76	3.71	3.67	3.63	3.59	3.55	3.50	3.46	3.42	3.38	3.34	3.29	3.25	3.21	3.17	3.13	3.08	3.04	3.00	2.96	2.92
74.5	3.85	4.02	3.87	3.83	3.79	3.75	3.71	3.66	3.62	3.58	3.54	3.50	3.45	3.41	3.37	3.33	3.29	3.24	3.20	3.16	3.12	3.08	3.03	2.99	2.95
75.0	3.89	4.06	3.91	3.87	3.82	3.78	3.74	3.70	3.66	3.61	3.57	3.53	3.49	3.45	3.40	3.36	3.32	3.28	3.24	3.19	3.15	3.11	3.07	3.03	2.98
75.5	3.92	4.09	3.94	3.90	3.86	3.82	3.77	3.73	3.69	3.65	3.61	3.56	3.52	3.48	3.44	3.40	3.35	3.31	3.27	3.23	3.19	3.14	3.10	3.06	3.02
76.0	3.95	4.12	3.98	3.94	3.89	3.85	3.81	3.77	3.73	3.68	3.64	3.60	3.56	3.52	3.47	3.43	3.39	3.35	3.31	3.26	3.22	3.18	3.14	3.10	3.05
76.5	3.99	4.16	4.01	3.97	3.93	3.89	3.84	3.80	3.76	3.72	3.68	3.63	3.59	3.55	3.51	3.47	3.42	3.38	3.34	3.30	3.26	3.21	3.17	3.13	3.09
77.0	4.02	4.19	4.05	4.00	3.96	3.92	3.88	3.84	3.79	3.75	3.71	3.67	3.63	3.58	3.54	3.50	3.46	3.42	3.37	3.33	3.29	3.25	3.21	3.16	3.12

APPENDIX D—PULMONARY FUNCTION STANDARDS FOR COTTON DUST STANDARD

The spirometric measurements of pulmonary function shall conform to the following minimum standards, and these standards are not intended to preclude additional testing or alternate methods which can be determined to be superior.

I. APPARATUS

a. The instrument shall be accurate to within ±50 milliliters or within ±3 percent of reading, whichever is greater.

b. The instrument should be capable of measuring vital capacity from 0 to 7 liters BTPS.

c. The instrument shall have a low inertia and offer low resistance to airflow such that the resistance to airflow at 12 liters per second must be less than 1.5 cm H_2O/(liter/sec).

d. The zero time point for the purpose of timing the FEV_t shall be determined by extrapolating the steepest portion of the volume time curve back to the maximal inspiration volume (1, 2, 3, 4) or by an equivalent method.

e. Instruments incorporating measurements of airflow to determine volume shall conform to the same volume accuracy stated in (a) of this section when presented with flow rates from at least 0 to 12 liters per second.

f. The instrument or user of the instrument must have a means of correcting volumes to body temperature saturated with water vapor (BTPS) under conditions of varying ambient spirometer temperatures and barometric pressures.

g. The instrument used shall provide a tracing or display of either flow versus volume or volume versus time during the entire forced expiration. A tracing or display is necessary to determine whether the patient has performed the test properly. The tracing must be stored and available for recall and must be of sufficient size that hand measurements may be made within requirement of paragraph (a) of this section. If a paper record is made it must have a paper speed of at least 2 cm/sec and a volume sensitivity of at least 10.0 mm of chart per liter of volume.

h. The instrument shall be capable of accumulating volume for a minimum of 10 seconds and shall not stop accumulating volume before (1) the volume change for a 0.5 second interval is less than 25 milliliters, or (2) the flow is less than 50 milliliters per second for a 0.5 second interval.

i. The forced vital capacity (FVC) and forced expiratory volume in 1 second ($FEV_{1.0}$) measurements shall comply with the accuracy requirements stated in paragraph (a) of this section. That is, they should be accurately measured to within ±50 ml or within ±3 percent of reading, whichever is greater.

j. The instrument must be capable of being calibrated in the field with respect to the FEV_t and FVC. This calibration of the FEV_t and FVC may be either directly or indirectly through volume and time base measurements. The volume calibration source should provide a volume displacement of at least 2 liters and should be accurate to within ±30 milliliters.

II. TECHNIQUE FOR MEASUREMENT OF FORCED VITAL CAPACITY MANEUVER

a. Use of a nose clip is recommended but not required. The procedures shall be explained in simple terms to the patient who shall be instructed to loosen any tight clothing and stand in front of the apparatus. The subject may sit, but care should be taken on repeat testing that the same position be used and, if possible, the same spirometer. Particular attention shall be given to insure that the chin is slightly elevated with the neck slightly extended. The patient shall be instructed to make a full inspiration from a normal breathing pattern and then blow into the apparatus, without interruption, as hard, fast, and completely as possible. At least three forced expirations shall be carried out. During the maneuvers, the patient shall be observed for compliance with instruction. The expirations shall be checked visually for reproducibility from flow-volume or volume-time tracings or displays. The following efforts shall be judged unacceptable when the patient:

1. has not reached full inspiration preceding the forced expiration,
2. has not used maximal effort during the entire forced expiration,
3. has not continued the expiration for at least 5 seconds or until an obvious plateau in the volume time curve has occurred,
4. has coughed or closed his glottis,
5. has an obstructed mouthpiece or a leak around the mouthpiece (obstruction due to tongue being placed in front of mouthpiece, false teeth falling in front of mouthpiece, etc.)
6. has an unsatisfactory start of expiration, one characterized by excessive hesitation (or false starts), and therefore not allowing back extrapolation of time 0 (extrapolated volume on the volume time tracing must be less than 10 percent of the FVC.)
7. has an excessive variability between the three acceptable curves. The variation between the two largest FVC's and FEV_t's of the three satisfactory tracings should not exceed 10 percent or ± 100 milliliters, whichever is greater.

b. Periodic and routine recalibration of the instrument or method for recording FVC and $FEV_{1.0}$ should be performed using a syringe or other volume source of at least 2 liters.

III. INTERPRETATION OF SPIROGRAM

a. The first step in evaluating a spirogram should be to determine whether or not the patient has performed the test properly or as described in II above. From the three satisfactory tracings, the forced vital capacity (FVC) and forced expiratory volume in 1 second ($FEV_{1.0}$) shall be measured and recorded. The largest observed FVC and largest observed FEV_t shall be used in the analysis regardless of the curve(s) on which they occur.

b. The following guidelines are recommended by NIOSH for the evaluation and management of workers exposed to cotton dust. It is important to note that employees who show reductions in FEV_1/FVC ratio below .75 or drops in Monday FEV_t of 5 percent or greater on their initial screening exam, should be re-evaluated within a month of the first exam. Those who show consistent decrease in lung function, as shown on the following table, should be managed as recommended.

IV. QUALIFICATIONS OF PERSONNEL ADMINISTERING THE TEST

Technicians who perform pulmonary function testing should have the basic knowledge required to produce meaningful results. Training consisting of approximately 16 hours of formal instruction should cover the following areas. Persons who successfully complete the course will be certified by OSHA or their designee.

a. Basic physiology of the forced vital capacity maneuver and the determinants of airflow limitation with emphasis on the relation to reproducibility of results.

b. Instrumentation requirements including calibration procedures, sources of error and their correction.

c. Performance of the testing including subject coaching, recognition of improperly performed maneuvers and corrective actions.

d. Data quality with emphasis on reproducibility.

e. Actual use of the equipment under supervised conditions.

f. Measurement of tracings and calculations of results.

(Secs. 6, 8, 84 Stat. 1593, 1599 (29 U.S.C. 655, 657); Secretary of Labor's Order 8-76 (41 FR 25059); 29 CFR Part 1911).

[FR Doc. 78-17232 Filed 6-19-78; 8:45 am]

[4510-26]

PART 1910—OCCUPATIONAL SAFETY AND HEALTH STANDARDS

PART 1928—OCCUPATIONAL SAFETY AND HEALTH STANDARDS FOR AGRICULTURE

Occupational Exposure to Cotton Dust In Cotton Gins

AGENCY: Occupational Safety and Health Administration, Department of Labor.

ACTION: Final standard.

SUMMARY: This final standard establishes mandatory occupational safety and health requirements for occupational exposure to cotton dust in cotton gins. It reflects OSHA's determination, based on evidence in the record, that exposure to cotton dust in cotton gins presents a significant health hazard to employees, necessitating federal regulation. This final rule establishes requirements for work practices, respirator usage, medical surveillance and recordkeeping, but does not impose a numerical permissible exposure limit. This occupational safety and health standard for exposure to cotton dust in cotton gins is issued in conjunction with the general industry standard for exposure to cotton dust published today also in Part III of this FEDERAL REGISTER.

EFFECTIVE DATE: September 4, 1978, except that some provisions are effective September 4, 1979.

FOR FURTHER INFORMATION CONTACT:

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SUPPLEMENTARY INFORMATION: This occupational safety and health

standard is issued under sections 6(b) and 8(c) of the Occupational Safety and Health Act of 1970 (the Act) (84 Stat. 1593, 1599; 29 U.S.C. 655, 657), the Secretary of Labor's Order No. 8–76 (41 FR 25059) and Title 29, Code of Federal Regulations (CFR) Part 1911. It amends Part 1910 of 29 CFR by adding a new § 1910.1046 entitled "Exposure to cotton dust in cotton gins," and amends § 1928.21 in 29 CFR Part 1928, to apply the new § 1910.1046 to agricultural operations. Thus, the new standard will apply to all cotton gins, whether considered agricultural operations or industrial operations.

I. Background—General

Cotton is commercially grown in at least nineteen states and is a major crop in fourteen. The states generally considered to be the largest producers of cotton are Texas, California, Mississippi and Arkansas. In 1973, with an average price of 44.6 cents per pound, nearly 13 million bales approximately 480 pounds were produced on nearly 12.5 million acres planted, for a production value of about $2.8 billion. In 1975 the average price has risen to 50.1 cents per pound, but production has declined to 8.3 million bales on 9.5 million acres planted, for a production value of about $2 billion. (U.S. Department of Agriculture, Agricultural Statistics, 1976, pp. 57–71).

Most of the crop is harvested and ginned in the fall and early winter. Almost 100 percent of total U.S. cotton production is now machine harvested by mechanical devices which remove the seed cotton from the ball. Machine-stripped cotton is harvested by mechanical devices which strip the entire cotton plant. Machine salvaged cotton is picked from the ground by special machinery. Strippers are used in the Blacklands and High Plains of Texas and in the cotton-producing areas of Western Oklahoma. Spindle-type pickers are used to harvest the crop elsewhere. Seed cotton that has been harvested mechanically by machine stripping or machine salvaging contains more trash and other contaminants than machine picked cotton. Harvesting is entirely outdoors, involves a small number of workers, and is in every respect a traditional agricultural operation.

Cotton as a crop has no intrinsic value until the seed has been removed by the gin. Thus, as soon as cotton is harvested it is usually hauled to a nearby gin. After the seed cotton arrives at the gin, it is exposed to multiple stages of conditioning and cleaning most, if not all, of which result in cotton dust exposures. Finally, the lint is separated from the seed and packaged into bales.

Cotton has traditionally been ginned in numerous small gins owned by farmers and located on the farm. In 1974 there were 3,262 gins operating in 16 states. More than half of these were small, with capacities of one to eight bales per hour, while less than 8 percent were large, with capacities of 19 or more bales per hour. The large gins had substantially higher profit rates and exhibited economics of scale for both stripper and picker types of gin. Revenues for the 1973–1974 season for the industry were estimated at $346.7 million, including $38.1 million for non-ginning activities (Ex. 88e). In recent years the total number of gins has declined sharply. At the same time there has been a steady rise in the demand for construction of modern gins with greatly increased capacity and more sophisticated equipment. With this consolidation of ginning capacity has come a shift in ownership of gins from individual farmers to co-operative associations. These co-op gins are centralized for service to members and customers.

The ginning of the cotton crop commences after the harvest. There appears to be some variation in the length of the ginning season depending to some extent on the individual gin and circumstances, but also on the particular growing region. Testimony for the National Cotton Ginners Association states:

> "Approximately 85 percent of the U.S. cotton crop is ginned between September 15th and January 15th. About 13 percent is ginned before this 4-month period and the remainder after January. For individual producing areas, harvesting may be completed within a 6–8 week period." (Ex. 88c, p. 6)

The ginning season generally parallels the harvesting. Other testimony approximates the length of the individual seasons in similar magnitudes: 4–6 weeks (Ex. 88d, p. 10), 4–8 weeks (Tr. 3833) and 5–12 weeks (Tr. 3826). In terms of worker exposure, U.S. Department of Agriculture statistics for 1976–77 indicate that a typical gin crew spent 78 percent of its total hours on the job within an 8 week period of almost constant work. Of course, these statistics do not reflect the time spent in more than one gin by migrant workers.

Local transient labor is a major source of gin workers in gins throughout the cotton belt. In the West this population is supplemented by a substantial number of migrant workers. Many of the jobs in the gin do not require skill or experience (Ex. 88, pp. 5–8). Often the turnover in these jobs is extremely rapid (Ex. 88, p. 5). It appears that some gin workers migrate from gin to gin.

The ginners who operate the gins and their assistants are skilled workers who return to the gin each year for longer careers than do the unskilled employees. In many cases the ginner remains on the farm in some other capacity or tends to the gin year around.

II. History of Regulation

The proposed standard for exposure to cotton dust was applicable to "all workplaces in all industries where exposure to cotton dust exists, including ginning * * *" (41 FR 56502). The provisions of the proposed standard, including the 200 $\mu g/m^3$ permissible exposure limit, applied equally to ginning and all other industries which handle and process cotton. During the hearing considerable testimony was presented on the properties and hazard of cotton dust regardless of its source of exposure. There was also major testimony and comment directed to the specific effects of cotton dust in ginning. While much of this testimony was presented at the hearing held in Washington, D.C. conducted from April 5–8, May 2–6, and 16–17, 1977, the two regional hearings in Greenville, Mississippi on April 12, 1977 and in Lubbock, Texas on May 10–12, 1977, attracted wide-ranging participation from the ginning community.

The written and oral testimony of all participants as well as the proposal and pre-hearing and post-hearing comments were made part of the rulemaking record. The hearing record was closed on September 2, 1977 (42 FR 39120).

In promulgating these final standards for exposure to cotton dust, OSHA has severed the ginning standard from the standard applicable to the other segments of the cotton industry which is being published with this ginning standard in Part III of this Federal Register. This separate standard for ginning reflects these unique characteristics of cotton ginning which necessitate somewhat different treatment from other segments of the cotton industry. While OSHA bases this standard on all the evidence gathered during the proceedings, separate standards are being established in order to avoid any confusion on the part of affected employers and employees as to the different provisions applicable to ginning.

While various exposure limits have been established for other segments of the industry, no specific permissible exposure limit has been set for ginning. On the other hand, provisions adapted specially for the ginning workplace, such as the requirement for bi-lingual training and education and the provision for apportioning the medical surveillance among employers in the case of employees, who move from gin to gin, would not be required of employers who did not operate gins. To avoid the confusion that might arise from including all these provisions in one regulation, OSHA has developed a separate standard for ginning.

Since the cotton dust standard for ginning and the rest of the cotton in-

dustry are the product of one rulemaking and are based on record, the preamble sections on Legal Authority and History of the Regulation published with the general cotton dust standard, as well as other relevant portions of that preamble, are equally applicable to ginning, and are incorporated herein by reference.

III. Health Effects

In the preamble to the general cotton dust standard, the health effects associated with occupational exposure to cotton dust are described in detail. The evidence in the record indicates that the respiratory diseases observed in all diverse segments of the cotton industry have also been found to exist among workers employed in ginning. Classical byssinosis, both the acute and chronic stages (Ex. 128A; Ex. 128B; Ex. 128D; Ex. 128E), and decrements in pulmonary function measurements usually associated with byssinotic symptoms (Ex. 128B; Ex. 128C); "Brit. J. Ind. Med." 22:291 (1965); Ex. 128D have been documented in several foreign studies of ginning employees. The one study based in the United States similarly found significant acute depression in lung function among ginners (Ex. 6, #59). The progressive nature of the disease has been noted for gin workers just as it has for textile mill workers (Tr. 839; Ex. 128A; Ex. 128B). Upon reviewing this scientific literature in the record, OSHA finds regulation of cotton dust in gins to be required under the mandate of the Occupational Safety and Health Act.

Even without relying on foreign studies, OSHA believes that the evidence of pulmonary effects in all other facets of the U.S. cotton industry alone would point to the existence of a causal relationship between cotton dust exposure and respiratory disease in the U.S. ginning industry. This is based on the view that the etiologic agent(s) found in the dust generated at all other stages of cotton processing are also to be found in the dust generated during ginning, and based on the evidence that the physiological response of cotton gin workers does not differ significantly from the response of other workers handling cotton. In other words, OSHA places heavy reliance on the evidence presented in detail in the Health Effects section of the general cotton dust standard in supporting the need for regulatory action to protect the health of cotton gin workers. OSHA believes that the results of the initial survey of the U.S. gin workers by Palmer et al corroborates the soundness of this view.

Claims for an exemption from the standard by representatives of the ginning industry based on the argument that no cotton dust induced respiratory disease exists in gins ignore the findings of numerous scientific studies in the record. Before discussing the findings in the U.S., it is appropriate to analyze the significant body of foreign studies of cotton gins.

Foreign Studies

Dr. M. A. El Batawi produced two studies based upon Egyptian gin workers (Ex. 128A; Ex. 128B). A 1962 study of 323 ginners in 11 gins founds a byssinosis prevalence (all grades) of 39.4% (Ex. 128A). Dust exposures were not reported although later testimony indicated that they were probably very high. Duration of employment averaged 8 years for these workers who ginned for six months each year. Symptoms usually appeared after 5 years (i.e. seasons) with 31% of all workers with less than 6 years of exposure reporting grade ½ or 1 byssinosis. If only those ginning more than 10 years are evaluated, then 65% of those with byssinosis are grade 2 or 3.

In a second study by El Batawi, byssinosis was present in 33% of 24 ginners surveyed (Ex. 128B). Dust levels indicated a mean exposure to total dust of 15.3 mg/m³. This second study included pulmonary function measurements. Ginners in dust had FEV 0.75 acute decrements of 190 mls while those out of dust had only 20 mls. Those with byssinosis lost 250 mls FEV 0.75 over the work shift. Pulmonary function tests were taken on the third day of the work week and, therefore, might be expected to understate acute effects. Comparison of standarized baseline measurements indicated significantly lower values for ginners than controls.

Gilson et al (Ex. 128C) studied a small number of workers in three gins in Uganda where a language barrier prevented evaluation of symptomatic byssinosis. Duration of employment was not stated but the populations were young on average (range 25–29 years) and worked generally only four months in a year. Exposure measurements were high particularly in "fifi" (dirty, moldy grade of cotton) processing. Actual exposures, however, were certainly lower as workers spent a significant portion of time outside the gins. Significant acute loss of FEV 0.75 (230 mls) occurred in workers ginning fifi and large (90 mls) loss occurred in one gin where workers were exposed to much lower levels.

Kondakis and Pournaras investigated the prevalence of byssinosis among a sample of 70 ginnery workers in Greece "Brit. J. Industry. Med." 22:291 (1965); Ex. 18, p. 2) No case of byssinosis was found but a statistically significant relationship was found between length of exposure and impairment of lung function. Workers with an exposure of 0–3 years (mean age of 46.7 years) exhibited a mean FEV_1 of 96.4% of predicted; workers with 4–8 years of exposure (48.0 years, mean age) exhibited a mean FEV_1 of 87.4% of predicted; after 9 or more years (50.0 years, mean age), mean FEV_1 was only 84.1% of normal. The mean age of the workforce, 49, was high. The Greek ginning season runs from September to May. The dust levels encountered were not presented.

Two studies (Ex. 128D; Ex. 128E) were done by Khogali in Sudanese gins where ginning occurs 6 months per year. The study population included 271 ginners and pressers, 52 ginning workshop workers servicing the gins, and a control group. The three populations had worked on average between 9 and 13 years. Both gin workshop workers and ginners experienced a prevalence of 20% byssinosis, 35 farfara workers experienced 49% and controls 0% (Ex. 128D). Byssinosis as defined here is based on chest tightness on the first three days of the annual work period, i.e. similar to grade 2. Workshop exposure was 0.11 mg/m³, gin exposure 0.63 mg/m³, and farfara 2.6 mg/m³ based on the hexlet of Roach measuring only particles less than 7 μm. Pulmonary function testing of FEV_1 showed controls gaining 230 mls during the work day while the workshop lost 40 mls and the ginners 100 mls on the average.

Khogali found a statistically significant association between the prevalence of byssinosis and the concentration of fine dust (less than 7μ) when comparing various ginnery workers and farfara workers. Also, there was a significant relationship between the mean adjusted FEV_1, the mean fall in FEV_1, and fine dust concentration.

Two years later a follow-up of this population was undertaken with almost all (96%) restudied (Ex. 128E). The resurvey took place after six months off and just prior to the next season's ginning. Age and height adjusted FEV_1 decreased slightly for controls but increased by 360 mls in the workshop and 450 mls in the gin. Byssinosis was shown to occur with the same prevalence as in the earlier study, and exposure measurements were also approximately the same in the second survey. Khogali developed a dose-response relationship between prevalence of byssinosis and level of dust concentration (dust less fly). Exposure history was also regressed against time. It is noted that the earlier work by Fox et al in the Lancashire textile mills provides almost identical results (Ex. 381 (Appendix 12, pp. 16–17)). Dr. Arend Bouhuys of Yale University commented on this data, as follows:

> Although conditions in the Sudan ginneries studied by Khogali differ from those in the United States, it is of interest that Khogali found about 11% byssinosis prevalence among a group of workers with a total dust

exposure experience of about 22 μg/years/m³. Thus, such a prevalence might be experienced among workers exposed to about 0.5 mg/m³ dust (less fly) during about 40 years. (Ex. 11, pp. 2-3)

It is clear from these studies that pulmonary effects have been observed in all foreign countries where ginning has been studied. These studies generally evidence an acute pulmonary effect, and, although chronic respiratory effects among ginners are less evident, these studies do not in general adequately address this problem.

While OSHA views these foreign studies as support for inclusion of ginning in an occupational health standard, the Agency acknowledges the uncertainty in relying too heavily upon studies based on worker populations and prevailing conditions found primarily in Egypt and the Sudan. First of all, review of these studies is complicated by dust measurements which, when included, cannot really be compared. In addition, the dust levels reported by El Batawi and Gilson et al especially for farfara or "fifi" are remarkably high. These high measurements appear to reflect the fact, as testified by Dr. El Batawi (TR 814), that foreign gins are likely to be relatively primitive, especially at the time when these studies were done. Also, foreign gins are likely to include many manual operations (TR 823-31) which increase the personal exposure of gin workers. Farfara is an extreme example of a hazardous manual process.

Second, the ginning seasons in Egypt (6 months), the Sudan (5-6 months) and Greece (7 months) are much longer than the season in a typical U.S. ginning region. It is true that some U.S. workers travel from gin to gin in the Southwest, but the maximum extent of the western season appears not to exceed 3 to 4 months (Ex. 88c, p. 6; See generally the section on *Background*).

Finally, the foreign ginning population, usually living in a village, appears to be more stable and, consequently, to continue in ginning longer than do their more transient U.S. counterparts. In Khogali's follow-up study (Ex. 128E), after 2 full years 96 percent of the study population were still employed, their number depleted by transfers, training courses and retirement rather than the attrition found in the United States (Tr. 3197-9). Data produced by Kondakis and Pournaras, and El Batawi et al., demonstrated the presence of many older ginners with long term service in the gin.

OSHA does not view this data as supplying unimpeachable dose-response relationships which would adequately describe the U.S. population. Indeed, Khogali's regression analysis (Ex. 128E, p. 173) does not even adequately describe the gin worker populations in neighboring countries. Even assuming the extrapolation of Khogali's data to predict a prevalence of byssinosis among ginners after 40 years to be valid, it grossly exaggerates the length of time the typical ginner appears to spend in the U.S. gin over a career. Therefore, OSHA has been cautious in its handling of foreign data to predict domestic prevalences of both acute and chronic byssinosis.

These differences notwithstanding, it is clear that pulmonary effects have been observed in all countries where ginning has been studied. It is only when the extent of these pulmonary effects is examined that the difficulty of intercomparing data from Egypt, Sudan, Greece, Uganda, and the United States becomes pronounced.

American Study

In contrast to this body of foreign studies, only one preliminary survey exists covering gins in this country. Palmer et al studied 203 gin workers and 260 controls (Ex. 6, No. 59; Ex. 18). No symptoms of byssinosis were reported on questionnaires although questionnaires were deemed to be unreliable by the investigators for reasons of language and circumstance (Ex. 18, pp. 30-31).

Spirometric monitoring of FEV_1 over the shift showed that 44 percent of the workers tested were classified as functional reactors. Of this number, 27 percent were moderate reactors (change in FEV_1 greater than 5 percent to 10 percent) and 17 percent were severe reactors (change in FEV_1 greater than 10 percent). Since many workers were never "out of dust" for the 48 hours before measurement, acute dust effects are probably underestimated. No correlation with dust measurement was found. Mean dust levels measured by vertical elutriator for Texas gins, New Mexico gins, and combined gins were 0.86 mg/m³, 1.03 mg/m³ and 0.93 mg/m³, respectively, and were generally uniform for work area. Duration of exposure averaged 13 years for the gin stand, 7 years for the baling press, 8 years for others, and 8.8 years for total workers. Workers at the gin stand were about 40 years old while other gin workers averaged 34 years. Reactors made up 44 percent of the 39 ginners with adequate $FEV_{1.0}$ measurements. These were exposed to average dust levels of 1.25 mg/m³ almost twice that of the pressmen who showed a higher proportion of reactors, 53 percent.

Controls were not tested for acute change in $FEV_{1.0}$. Review of $FEV_{1.0}$ baseline values suggest no major difference between exposed workers and controls in several gins scattered over a wide geographical area. The Palmer study failed to detect any classical byssinosis (Ex. 18, p. 22) or excess chronic respiratory disease (Ex. 18, pp. 12-13). As stated earlier, failure to overcome communication difficulty with the predominantly Spanish speaking workforce (Tr. 762) and worker concern that their employment could be jeopardized (Tr. 789-91), was the author's explanation for the lack of response to the questionnaire where the question related to the gin's effect on health. Impressive data has been produced on functional reactors. A significant percentage (18.7 percent) of the population studied exhibited pulmonary function losses that qualify them for a removal from exposure according to generally accepted medical criteria (Ex. 18, p. 35). In many cases, decreases in objective pulmonary function measurements have been shown to accompany subjective symptoms such as chest-tightness or breathing difficulty (Ex. 6, No. 18, 19, 3, 24). The failure to report any subjective symptoms is peculiar, and, as stated by Dr. Palmer, might merely represent refusal to admit adverse health effects despite clearly observable suffering (Tr. 804-5).

The Palmer study is consistent with the foreign studies in a number of respects. It demonstrates clear evidence of acute pulmonary effects. The extent of the hazard in the U.S., is similar to that reported by other researchers, Dr. El Batawi for example (Ex. 18, pp. 35-36). In every country where exposure to cotton dust in ginning has been studied, an occupational hazard has been demonstrated. Although chronic respiratory effects have not always been demonstrated, the studies do not adequately address the problem and, indeed, there is no reason to believe that the chronic stage does not develop progressively from the acute stage in ginning as has been evidenced where adequate data has been developed. Indeed, Dr. Palmer has endorsed this conclusion (Tr. 765). Upon reviewing this body of evidence, OSHA concludes that occupational exposure to cotton dust in ginning is a hazard that must be regulated. Worker health in U.S. cotton gins must be safeguarded by inclusion of their work places within the scope of the cotton dust standard.

Once it becomes clear that ginning must be included in the standard, the question of what level of protection should be required arises. Should the standard for ginning include a numerical permissible exposure limit, or is it more appropriate to provide protection to ginning workers through work practices, medical surveillance, etc, without setting a numerical limit? OSHA recognizes that determining what exposure is adequately protective of U.S. gin workers is, a much more difficult question than whether gin workers need some means of protection from cotton dust exposure. This difficulty follows from the lack of any dose-response data covering the

U.S. ginning population. The Palmer study did not quantify dose and response in the sample population studied (Ex. 18, pp. 20, 26). Without adequate dose-response data, OSHA is forced to draw inferences from the Palmer work and the foreign studies in the record, or from the dose-response data gathered on the textile industry. Numerous factors cast doubt on the numerical inferences drawn from these data.

Initially, OSHA recognizes the evidence of a seasonal pattern of exposure associated with ginning which mitigates the extent of cotton dust exposure (e.g., Ex. 11, p. 3; Tr. 816–817). The impact of seasonal exposure is to decrease the total exposure and to allow recovery of lung function during the off-season. Khogali's work demonstrates dramatic recovery in the baseline FEV_1 after 6 months of removal from exposure (Ex. 128E, pp. 169–70). Dr. El Batawi testified that the interruption in exposure probably causes a relative increase in acute symptomatology and a decrease in advanced symptoms compared to the distribution of prevalences found in textile operations (Tr. 816–17).

There is evidence in the record that the average U.S. gin's season lasts from 5 to 12 weeks (Ex. 88c, p. 6; See *Background*, generally). While some workers might migrate from one cotton growing region to another as the season progresses, the maximum extent of the season is unlikely to exceed 6 months for a fraction of the workforce. It should be noted that the record contains only passing reference to workers' movement (e.g. Ex. 88, p. 5); no definitive data on migratory patterns among gin workers is available. Nevertheless, it would appear that the vast majority of employees of U.S. gins experience a briefer exposure to cotton dust and enjoy a longer period to recover during the off-season than do their Egyptian and Sudanese counterparts.

On the other hand, there is testimony that lung function is not totally recoverable, and that the long-term effects of even brief intermittent exposure could be harmful to the worker (Tr. 839–40). As Dr. El Batawi stated on this point in reference to the "total recoverability" of workers intermittently exposed to cotton dust:

> So, at one stage, in the early stages, you have certain changes. When you suspend exposure they are reversed completely. The person becomes normal. But then if you repeat the exposure again, his ability to combat that is most probably less than when he was originally normal to begin with (Tr. 840–41).

The connection between acute and chronic health effects among gin workers is generally not as well understood as it is for workers in the textile industry, although Dr. El Batawi expressed the opinion that the same general process of gradual pulmonary insult and deterioration was occurring despite the seasonal break. A review of the research done in cotton gins reveals an acute dust response in many places where exposure has been studied, whereas there appears to be less conclusive evidence of widespread chronic obstructive pulmonary disease. There are several explanations for this scarcity of data on chronic disease effects. As stated above, the studies in the record do not on the whole adequately address the problem. There is evidence that a "healthy worker effect" diminishes the number of severely affected workers in the study population (Tr. 806–7). Thus, in the case of the U.S. ginning industry, the return of Mexican nationals to their homeland may be a confounding factor in determining the extent of cotton dust related disease in the U.S. (Tr. 765, 806–7). In the U.S. the failure to seek out retired gin workers may explain the lack of data (Tr. 765).

The most significant factor might be the length of the average worker's career in a U.S. gin compared to that of Egyptian or Sudanese workers. El Batawi's work indicates a noticeable prevalence of grades 1 and 2 byssinosis only after several years (i.e. seasons) of exposure (Ex. 128A; Ex. 128B), although in testimony he stated that the length of time was not conclusive (Tr. 834). In light of Palmer's data indicating an average U.S. exposure of only 7–8 years for workers other than the skilled gin stand operators, it is possible that the average gin worker leaves the worker pool before the development of chronic symptoms. Those who remain in the gins the longest, the gin stand operators, represent a hardier group (older, with longer career, but with reduced pulmonary sensitivity in the face of relatively higher exposures than other workers) which exhibits the characteristics of a typical "survivor population" (Ex. 18, pp. 31–32). All of these explanations, however, are speculative in view of the lack of adequate research into the effect of seasonality on the prevalence of cotton dust induced respiratory disease among the U.S. ginning population.

In summary, there is convincing evidence of acute pulmonary effects in almost all studies of ginning, including one in the United States. Not only are acute effects often of considerable magnitude (44 percent acute reactors according to Palmer), but there is testimony indicating that the seasonal break may not totally restore lung function, especially after the repeated exposures of several seasons (Tr. 839–40; Ex. 11, p. 3). For sensitive individuals, the acute effects may appear after the passage of only a few seasons (Ex. 128A).

While there is evidence of chronic respiratory effects in foreign gin worker populations, such evidence is yet to be gathered in this country. The preponderance of evidence on cotton dust exposure is sufficiently consistent to predict a relationship between acute and chronic effects. However, the moderating effects of the U.S. gin season and the relatively brief career of the ginning population which might affect the development of chronic obstructive pulmonary disease are not satisfactorily well researched to draw any firm conclusions about the prevalence of chronic disease.

OSHA views all the evidence on adverse health effects in the ginning operation as requiring the development of a standard on cotton dust exposure for the ginning industry. The ginning workforce in the United States is clearly suffering a high prevalence of acute respiratory dysfunction which has been shown in studies of other U.S. cotton industries and in foreign ginning industries to develop into a state of chronic obstructive pulmonary disease. Although no chronic disease has been documented among the domestic gin workforce, the reason may be merely the inadequate epidemiological research into the problem. OSHA believes that any uncertainty in the data on health effects must be resolved in favor of worker protection despite some factors suggesting that a lesser degree of protection might be needed in ginning than in other cotton processing industries.

IV. Control of Exposure

The standard provides for worker protection from exposure in gins primarily through the implementation of work practice controls and respiratory controls. This approach to employee protection also relies heavily on medical surveillance and employee education and training provisions, adapted for the unique working environment found in the ginning industry. Where appropriate, effective implementation of some of these provisions will call for a bilingual program.

In developing this strategy for worker protection in gins, OSHA is not establishing any specific numerical limit on exposure which it would deem to protect all workers in U.S. gins. Instead of requiring a specific exposure limit in this industry, the Agency has determined to depend on dust control technology in the more flexible context of work practice controls. Adoption of this strategy for the ginning segment of the cotton industry reflects OSHA's consideration of the unique conditions prevailing in ginning which have been amply demonstrated in the record.

Before determining that the limited epidemiological data in the record is inadequate for the purpose of specify-

ing a permissible exposure limit in ginning, OSHA weighed several strategies employing a numerical level ranging from 200 $\mu g/m^3$ to 1000 $\mu g/m^3$ lint-free respirable dust.

OSHA has considered treating ginning simply as another component of the non-textile cotton industry, and as such, subject to the 500 $\mu g/m^3$ permissible exposure limit. In one sense, the data on ginning compares with the evidence in other non-textile industries. Qualitatively, there appears to be acute respiratory dysfunction occurring in worker populations exposed to cotton dust, while quantitatively, there is incomplete data on dose-response. Beyond this broad similarity, however, the employee exposure and reaction characteristic of the gin is so clearly distinguishable from the pattern of exposure reported for aggregate non-textile industries that a different approach is clearly appropriate in this industry.

The primary distinguishing variable in ginning is the pattern of exposure. In the Health Effects section, the effect of interrupting employee exposure for 3 to 9 month periods was addressed. Development of acute byssinotic symptomatology is retarded and lung function is generally recovered during the off-season. The brevity of the average worker's career in the gin has the further effect of removing many workers from exposure before the onset of chronic obstructive pulmonary disease. Until adequate dose-response data is developed, OSHA has no evidence of chronic respiratory disease among gin workers exposed to current levels of dust in U.S. gins.

The permissible exposure limit applicable to the non-textile industry is also an inadequate benchmark for establishing an exposure limit for gins for several other reasons beside the critical difference between brief, intermittent exposure and constant, year-round occupational exposure to cotton dust. In general, the working gin environment rather than being confined within the building is coextensive with the duties of the typical gin hand (Ex. 88, pp. 6-8). To the extent that an average gin worker spends half of his time outside the shed, moving bales or performing other functions, he is receiving a lower dose of dust than he would if he were confined to the interior, dustry environment. Thus, an expert witness testified that a technological solution based upon the enclosure of the gin could in actuality increase the time-weighted exposure of the gin workforce (Ex. 88B, p. 7).

OSHA does not consider the reasoning used to set a permissible exposure limit in non-textiles as applicable to ginning. Furthermore, OSHA does not believe that the data in the record meaningfully points to any specific exposure level.

OSHA sees no evidence for applying a lower exposure limit in ginning than in any other non-textile industry for all the reasons enumerated above. In addition, the testimony on economic and technological feasibility in the record demonstrates the momentous impact which application of the 200 $\mu g/m^3$ permissible exposure limit to cotton gins would produce (see the discussion of Economic Feasibility). While not giving undue weight to this type of evidence in determining what level or whether any level constitutes a safe exposure, the Agency will not ignore these feasibility findings, especially where reliable evidence or inferences of severe health effects is not available.

OSHA has considered setting a higher exposure limit for ginning than other non-textiles, in a manner which would provide an appropriate margin of safety while at the same time giving due consideration to the unique exposure pattern in ginning. However, any attempt to set a level without adequate data involves speculation. Also, in view of the vast differences in harvesting and ginning methods, varieties of crops grown, and other regional differences, a level designed for the High Plains of Texas might be seriously inadequate for other regions of the country. OSHA concludes that the sparse data in the record does not support the establishment of any permissible exposure level which would provide the first order of protection for gin workers that the permissible exposure limits in carding, slashing and waste utilization provide for their respective workers.

In view of the above, OSHA has concluded not to set a numerical permissible exposure limit for cotton gins. The Agency believes, however, that the provisions of this standard specially modified to address the pecularities of the ginning industry will afford an acceptable margin of safety for ginning employees. Further, the provisions of the standard reconcile the demonstrated health needs of gin workers with methods of protection which are feasible and appropriate under the conditions unique to this segment of the cotton industry.

Since the reduction of acute respiratory symptoms is a major target of the standard, the work practices provision should achieve a marked lowering of subjective and objective reactivity margins. Actually, work practice controls as mandated in this standard embrace a variety of approaches to reducing exposures. One approach emphasizes the traditional housekeeping aspects of dust suppression. For example, ritual "blow down" operations would be forbidden except when other workers were absent from the area. A second approach stresses proper upkeep and maintenance of the gin's pneumatic production equipment. If the integrity of ducts and seals is maintained, the enclosed machinery can be expected to provide its own intrinsic dust control. This is especially true where the machinery imparts a negative pressure to the flow of cotton. The effectiveness of these measures should be enhanced by the participation of an informed work force. OSHA believes that the employee education and training provisions should apprise the workers, in Spanish where appropriate, of the purposes of these exposure protections.

The medical surveillance program has been designed to detect acute subjective and objective dust effects and, where appropriate, to follow the worker's movement from gin to gin, and over multiple seasons. In the absence of a medical removal provision in the standard, employers are not required to remove sensitive workers to low exposure stations; however, OSHA encourages voluntary movement of employees who have been identified by medical screening. In this respect, the abundance of primarily open-air jobs should facilitate voluntary removal or minimization of exposure for byssinotic employees or reactors. The standard also requires employers to provide respiratory protection for affected workers. Respirators, especially the minimally burdensome single use variety, have been shown to help in reducing dust exposure and suppressing the effects of cotton dust.

All of these controls, if conscientiously implemented, should have a substantial positive impact on reducing the acute effects of cotton dust. Evidence in ginning and in other areas of cotton processing demonstrate significant recovery from acute reactions following removal from or suppression of cotton dust (Ex. 128E; Tr. 1665, 1679).

Since little or no excess of chronic obstructive pulmonary disease was reported among the U.S. population studied, it appears that the medical surveillance system should be an effective mechanism for isolating any workers who may be in danger of developing an advanced state of respiratory degeneration. Furthermore, it is unlikely that many ginning workers will be unable to wear a respirator because of chronic pulmonary impairment.

Several parties have argued that a regulation of cotton gins must take into account the ambient dust levels in the vicinity of most gins (Tr. 3119; Tr. 3135; Ex. 159). The basic design of gin equipment necessitates the drawing of outside air into the gin building. This make-up air required by the gin machinery includes ambient dust (Tr. 3135). Thus, fugitive dust has been shown to contribute an undetermined amount of background dust to the gin environment which is not for the most

part distinguishable by the type of sampling device required for monitoring of cotton dust. Representatives of the ginning industry have recommended that background dust levels should be subtracted from the level of dust measured inside the gin if dust levels recorded were to be a fair measure of exposure to cotton dust (Tr. 3168–9). Several problems inherent in this approach, such as uncertainty over the appropriateness of the vertical elutriator as an environmental sampler, persuade OSHA to discount site-by-site corrections for background dust (Tr. 3658–61) which admittedly can be a problem of some magnitude on the farm. Instead, any permissible exposure limit developed for ginning should appropriately include a numerical factor acknowledging the uncertainty of the dust composition monitored inside the shed, and the uncertainty of industry's ability to design systems to exclude fugitive dust. OSHA's decision not to impose an environmental limit obviates the need to estimate, on the basis of conflicting data, the influence of background dust, ways to monitor ambient levels, and appropriate correction or industry's technological capacity for screening background dust out.

OSHA has evaluated the evidence of health effects, feasibility, both technological and economic, and the applicability of the provisions required under industry-wide cotton dust standard to ginning. OSHA has concluded that the evidence in the record supports the soundness of measures taken in this section on ginning, but not the imposition of any numerical environmental limit. OSHA also declares its intention to review the standard if sufficient evidence is presented demonstrating either the inadequacies of the current standard for the purpose of protecting worker health, or the need for a quantitative measure of exposure in the gins of the United States. OSHA will review this standard at the end of five years, or earlier if sufficient evidence of the need for a specific exposure limit is presented. In the meantime, OSHA is requesting NIOSH and the U.S. Department of Agriculture to accelerate efforts to explore the hazard in this industry and to develop engineering controls and alternatives for meeting any greater hazards that may be revealed by future research.

OSHA has attempted to employ different strategies, where the evidence justified such treatment, in the control of the hazards documented in each phase of cotton processing. In ginning, it has attempted to mandate a regulation which takes into account the unique characteristics of this industry. This approach, and the special provisions for medical surveillance and employee education and training reflect OSHA's efforts to apply some flexibility to regulating exposure to cotton dust in all workplaces.

V. Feasibility Issues

General

In setting standards for toxic substances, the Secretary is required by section 6(b)(5) of the Act to give regard to the question of feasibility. Section 6(b)(5) mandates that final standards be set which most adequately assure employee safety and health "to the extent feasible, on the basis of the best available evidence" and further requires that, in the development of occupational safety and health standards, "considerations shall be the latest available scientific data in the field, the feasibility of the standards, and experience gained under this and other health and safety laws."

While the precise meaning of this term is not clear from the Act or the legislative history, it has generally been construed in a standard-setting context to include both technological and economic considerations. The determination that OSHA has the authority to consider economic feasibility factors in developing standards has been endorsed by the courts, *Industrial Union Dept., AFL–CIO* v. *Hodgson*, 499 F. 2d 467 (C.A.D.C., 1974); *AFL–CIO* v. *Brennan*, 530 F. 2d 109 (C.A. 3, 1975); *AISI* v. *OSHA*, —— F. 2d —— (C.A. 3 Nos. 67–2358 et cetera, March 28, 1978). As pointed out by the D.C. Circuit Court of Appeals, Congress did not intend the Secretary to promulgate standards which drive entire industries or large numbers of employers out of business. On the other hand, "standards may be economically feasible even though, from the standpoint of employers, they are financially burdensome and affect profit margins adversely; further, the Court said, the concept of economic feasibility does not "necessarily guarantee the continued existence of individual employers. It would appear to be consistent with the purposes of the Act to envisage the economic demise of an employer who has lagged behind the rest of the industry in protecting the health and safety of employers and is consequently financially unable to comply with new standards as quickly as other employers." *Industrial Union Dept., AFL–CIO* v. *Hodgson*, supra, at page 478.

In accordance with the Secretary's position, it has long been OSHA's practice to analyze the economic and technological feasibility of proposed standards, to make such analysis available to affected parties for comment and subsequent hearing prior to issuance of final rules, and to invite the submission of other information on the technological and economic impact and feasibility of proposed standards. In developing a final standard, therefore, OSHA evaluates the economic feasibility of the final standard on the basis of the information developed by its own studies of the proposal and submissions by the public during rulemaking.

To assess the feasibility of the proposed standard for cotton dust, including the impact on ginning, OSHA undertook a study of the proposal's economic impact on the affected industries. This study was conducted for OSHA by the Research Triangle Institute (RTI)(IIS). Additional information was obtained through OSHA's analysis and consideration of all other technological and economic data, comments, arguments and testimony submitted at the hearings, in pre-hearing comments and in post-hearing comments and briefs. On the basis of the best available evidence, therefore, OSHA has determined, as explained in detail below, that this standard is technologically and economically feasible.

OSHA contracted for a study of the technological feasibility, cost, and economic impact of the proposed cotton dust standard, and an assessment of the impact of the proposed standard at permissible exposure levels of 500, 200, and 100 $\mu g/m^3$ measured as a time-weighted average by vertical elutriator (Ex. 16) was made. This study included assessment of the technological feasibility and economic impact of these levels of cotton ginning. OSHA's decision to control employee exposure to cotton dust in gins without reliance upon a permissible exposure limit, in effect, eliminates technological feasibility considerations from this standard.

Economic Feasibility

The bulk of testimony directed toward ginning was related to questions of the technological and economic feasibility of meeting the 200 $\mu g/m^3$ exposure limit and other requirements of the proposed regulation. Economic feasibility was heavily dependent on technological considerations since measures such as sealing of gin plants to exclude external dust, and moving and filtering external air for use in gins were very costly. Such measures were included in industry estimates of capital and annual costs of compliance with the proposed regulation, described in detail below. In view of the determination not to impose a specific permissible exposure limit, in the ginning industry, much of the discussion of economic feasibility in the rulemaking proceeding is not directly relevant to the feasibility of the final standard since engineering controls are no longer required. The industry's projected level of costs and uncertainty as to the availability of capital financing led to an estimate that 1952, or 69 per-

cent of the gins operating in 1974, would go out of business if the proposed requirements were incorporated in the final regulation and if there were no changes in the prices of ginning services (Tr. 3242-3243).

In addition, it was noted that a substantial portion of the fiber output is exported to foreign markets. The testimony indicated that the costs of compliance with the proposed regulation would be the equivalent of giving foreign producers a competitive advantage, and that this would make it impossible to maintain export sales (Tr. 3242-3243).

In 1974, exports included nearly 4 million bales of the total U.S. production of more than 11.5 million bales. U.S. exports constituted more than 30 percent of the world exports of cotton in 1974; U.S. cotton imports were less than 40,000 bales (U.S. Department of Agriculture, "Agricultural Statistics 1976," pp. 57-71). Recently, export sales have risen. In the 1976-1977 export season, exports were 4.4 million bales, and, in the 1977-1978 season, more than 5.7 million bales. The recent weakness of the dollar in international currency markets and a shortage of high quality grades of cotton in foreign countries have been cited as reasons for recent increases in shipments and prices of cotton.

As a result, there appears no reason to expect any significant decline in the overall demand for cotton, even though other factors, including the OSHA regulation of cotton dust in industries other than ginning, may have some effect upon domestic cotton consumption. Moreover, as discussed in detail below, the estimated costs of compliance with the provisions of the final regulation of exposure to cotton dust in gins is a small fraction of the anticipated costs of the proposed regulation. Therefore, especially in the absence of capital cost requirements, there is no apparent reason to expect either an acceleration of the declining secular trend in the number of gins or impetus toward substitution of other crops for cotton as a result of the final regulation of worker exposure to cotton dust in gins.

Such effects have been a matter of concern to OSHA in framing the regulation. Especially at the field hearings on the proposed standard, there was substantial testimony on the dependence of area economics in the cotton belt on the viability of the ginning industry which would make continued cotton production economically feasible. OSHA believes that the provisions of the final regulation achieve reasonable levels of protection of gin workers exposed to cotton dust without significant economic effects.

Costs of Compliance

The major economic effects of the regulation of worker exposure to cotton dust in gins result from the imposition of compliance costs upon the firms in the industry. As a result, these costs are reviewed in detail before the other anticipated economic effects of the regulation are discussed. The total cost of compliance for the final regulation is estimated by OSHA to be $1,850,213 for the first year and $1,717,566 for ensuing years. This is an average of $659 per gin the first year and $612 per gin annually thereafter. OSHA does not consider these costs to be significant.

For cotton ginning, RTI indicated that its estimates of costs were not exact, but were to provide a "relative idea" of the costs and effectiveness of control systems (Ex. 16, p. V-20). However, RTI did develop methods for estimating costs of compliance with most provisions, and these methods were then used by many who testified on the results of independent estimates for different sectors.

OSHA's estimates of total costs for compliance with the final standard are much lower than estimates of the proposal's compliance costs because the standard in its final form differs from the proposal in areas which significantly impact on the cost of compliance. The primary difference is that the proposal would have required all ginning employers to reduce employee exposure to cotton dust to 200 $\mu g/m^3$, whereas the final standard does not contain a permssible exposure limit, and therefore does not require either the institution of engineering controls or monitoring.

Among those who presented cost date were representatives of Natural Fibers Economic Research (NFER) of the University of Texas. NFER prepared a report for the National Cotton Ginners Association, "Economic Impact of OSHA's Proposed Cotton Dust Standard on Cotton Gins," March 1977, (Ex. 88e), which represented a thorough study in which their assumptions and calculations were clearly provided. More recent data were used by NFER, applying RTI methods, for estimating the costs of various provisions, and NFER developed its own models for certain elements.

As noted, the final regulation for cotton gins is significantly different from the proposed regulation, and it was necessary for OSHA to calculate the costs of the final regulation in the light of such differences. The method for that calculation was to change assumptions where necessary, and to recalculate the cost estimates for relevant provisions on the basis of the NFER report. The results of those recalculations are presented below, separately for each relevant provision of the final regulation and for total costs, and they are contrasted with the NFER estimates of the costs of the proposed standard.

Medical Surveillance

The regulation requires that each ginning worker be subject to two medical examinations each season by or under the supervision of a physician. Both RTI and NFER estimated the costs of the proposed regulation's medical surveillance program using similar methods; their assumptions differed principally on the basis of the numbers of gins and workers involved, since RTI estimates were based on earlier data. Both assumed a 25 minute preplacement examination performed by a nurse, and NFER noted that the 1974 average gin payroll included 7 workers per shift and 14 new workers hired each year to fill those positions; because of labor turnover during each season, an average of 21 workers per gin are employed to fill 7 positions. On that basis, NFER calculated the total costs of initial, preplacement examinations as equal to $149,948 as noted in Ex. *88e*, p. 31. RTI estimated this total cost at $127,774.

This initial (annual) examination process also includes informing each new employee whose initial screening indicated increased risk from cotton dust exposures as a result of smoking or a history of respiratory problems. Under the assumption that half of the tested workers would require 15 minutes of counseling, shared equally by doctors and nurses, NFER calculated counseling costs as equal to $94,822 as noted in Ex. *88e*, p. 31, while RTI estimated this cost at $78,843 (IIS, Vol. II, B-11).

NFER estimated capital costs of purchasing a spirometer at $727.50 for each of 3,262 gins, at a total $2,373,105, (RTI total estimate $2,557,617) and costs of training nurses to perform these tests, $267,518. The summary of NFER medical surveillance costs, then, included: Spirometer capital costs of $2,373,105, first year operating costs of testing, retesting, counseling and nurses' training, $740,318 and recurring annual costs for testing, counseling and retesting, $466,780, (RTI estimate for recurring annual costs was .8 million). These estimates reflected the provisions of the proposed regulation under the assumptions made by NFER.

OSHA views some of the NFER assumptions as unrealistic in their application to the final regulation and, thus, as overstating the costs of medical surveillance. For example, NFER's estimates are based on the 3,262 gins operating in 1974, while they reported 2,808 active gins in 1977. Given the secular decline in the number of gins, even the 2,808 figure is likely to be an overstatement of the number that can reasonably be expected to comply with the final regulation. For these reasons, the NFER estimates would overstate anticipated costs of the proposed regulation.

On the other hand, some of the assumptions probably understate costs. For example, the assumed worker wage rate of $2.30 an hour is likely to have increased by 25 to 30 percent by 1977. Moreover, the final regulation requires that workers be subject to two examinations in each season. This will raise the cost of medical surveillance, although it is not expected to double the relevant costs of the examinations for two reasons both related to labor turnover. Many workers subject to the first examination will leave employment before the time for the second. In addition, a worker who leaves one gin for employment in another need not be subject to reexamination in the second gin since he may substitute records of prior examinations in the same season for new examinations. These factors can be expected to reduce the cost impact of the requirement for a second examination each season by at least 50 percent of new hires.

OSHA has therefore recalculated the annual costs of the medical surveillance program by making appropriate changes in the estimates of NFER. The estimated total costs for the initial examination are, $639,674. This includes: For continuing workers, $39,877 based on 4 workers per gin for 2,808 gins; for new hires, $109,804 based on 17 workers per gin for 2,808 gins; counseling, $109,635 based on half the total of continuing workers. The total cost of retesting is estimated at $1,066,643 (for the examination, $124,314 based on 4 continuing workers and half of 17 new hires per gin for 2,808 gins; for counseling, $75,951; ventilatory capacity tests, $155,849; pulmonary function tests, $70,555). For the initial examination, it is assumed that no more than four workers per gin, more than half of the average number of positions, would be continuing workers. In fact, that number is substantially lower in most cases, since few employees continue working beyond the ginning season and are therefore likely to be considered to be eligible for pay for the examinations. The estimated average wage rate for them has been increased to $3 an hour. Further, the estimate is based on the 2,808 gins active in 1976–1977, rather than the number operating in 1974. The NFER assumption on physicians' and nurses' time and wages for these examinations has not been changed; while such wage rates have risen, it is expected that many of these functions may be performed by paraprofessionals such as respiratory technicians or others who may not have the full level of training required for nursing. The number of new hires, total tests and those counseled reflect the average of a total of 21 W-2 forms per gin, as noted by NFER for 1977. However, the recalculation does not use the NFER assumptions that counseling and retesting of continuing or current workers are included in the costs for new employees.

It is unlikely that as many as half of the 17 newly hired workers would be employed for a sufficiently long period to be subject to the second examination. The assumption that half of these will take that examination may overstate such costs. Counseling costs for 50 percent of those tested are again estimated. Counseling may be even more significant for those taking the second examination because they will have been exposed to the cotton dust in ginning, but some of those affected are expected to have quit on that account, as well as for other reasons, before they are subject to the second examination. Costs of testing ventilatory capacity and pulmonary function are estimated for all who are subject to the second examination. Costs per test for the second examination are the same as those for the initial one, except that payment of workers' wages for testing time is assumed for all who take the second examination.

The results of these recalculations are noted above, and they may be compared to the NFER estimates. Recurring annual costs for the first examination are recalculated to a total of $639,674, which is $172,894 or 37 percent higher than the $466,780 NFER estimate of continuing annual costs of testing but lower than the .8 million estimate by RTI. NFER did not explicity calculate such costs for continuing workers, and instead such costs were assumed as part of those for new hires. Moreover, NFER estimated examination costs for 14 workers per gin, when the average number of total hires was 21. The effects of higher worker wage rates and a higher estimate of workers per gin to be tested more than offset the reduction in the estimates of the appropriate number of gins and of the proportion of workers to be paid for examination time.

It appears unlikely to OSHA that many gins would, independently, be required to buy a spirometer or to pay for nurses' training for the program. Instead ginning employers would contract with units offering medical surveillance services which are able to ecomomize on the use of equipment and trained staff currently in short supply and to substitute paraprofessionals for some functions, or ginning employers would join together to set up their own mobile units. Even with any added costs for mobile operations it is unlikely that even half of the capital and first year training costs estimated by NFER would be passed on as charges to the gins. If half of such costs were to be involved, this would amount to $1,137,000 for first year or investment costs of those providing the services. If such costs were annualized on the basis of NFER assumptions (9.2 percent interest rate, 10-year depreciation period for capital), the annual charges to be passed back to the gins would be $206,745. Addition of this amount to the annual costs of examinations, $1,066,969, would result in an estimate of total annual costs of $1,273,714, or an average of $453.60 a year per gin. While this amount for both required examinations is substantially higher than the NFER estimate of annual costs per gin ($466,780 for 3262 gins, or $143.10 per gin), it would be relevant for the first year, for which NFER estimates would be $740,318 per 3262 gins or $226.95 for operating and maintenance costs for one examination for each new worker plus $727.50 for capital costs of a spirometer.

Respirators

The proposed regulation would have required the use of respirators in gins which failed to achieve the permissible exposure limit. Further, use of disposable respirators in gins was not generally acceptable under the criteria of the proposed regulation. As a result, NFER estimated the costs of personal protective equipment as including capital expenditures for half mask reusable respirators and annual costs for filter replacement and maintenance. The estimated costs were $495,269 for capital expenditures and $1,582,396 for recurring annual expenditures.

However, the final regulation does permit the use of disposable respirators. Also, in the absence of a permissible exposure limit, such use is required only for gin workers affected by cotton dust or engaged in specific practices such as equipment blowdowns. Under these requirements a respirator must be available for each employee, but it is unlikely that as many as half of the gin workers would use them on a daily basis. NFER noted there are seven work positions in the average gin. In the calculation of annual costs of respirators, NFER assumed 42 days as the number of working days per gin. It is reasonable to assume daily replacement of a disposable particle respirator, similar to the NFER assumption of daily filter replacement and maintenance of a reusable respirator. However, there would be no capital costs or maintenance for use of disposable respirators which many gins currently provide for workers who wish to use them.

The 1978 price for disposable particle respirators in small quantities was $13.33 for a box of 20 units, or $.6665 each. Under these assumptions, then, the cost of respirator use by affected workers in 2808 gins would be calculated as: 7 positions×½ (affected workers)×2808 gins×42 days×$.6665/respirator=$275,115 for the industry, or

$98 a year for the average gin. This amount is substantially less than the NFER estimate because of differences in the assumptions on the numbers of gins and of affected workers as well as the difference in the nature of the required respirator.

Work Practices

The regulation requires delineation and posting of specific work practices for all work positions where cotton dust is present. In most cases, it is expected that there will be little or no effect on productivity or costs of the specific practices, such as the reduced use of blowdown, and that other practices relate primarily to housekeeping efforts that are normal in most facilities. As NFER noted, some changes in practices may reduce efficiency while others may increase productivity. Therefore no specific costs are estimated for any productivity losses in implementing the work practices prescribed. However, some additional costs for establishing the work practices and for training of supervisors and workers in their use will be incurred.

NFER estimated such costs. It is assumed that an industrial engineer would require 16 hours to do a study of each of three work positions (gin stand, lint cleaners and the bale press area) in each gin and will require 15 minutes of secretarial time for each position. On that basis, assuming $5.25 and $2.60 as hourly wage rates for engineers and secretaries and a 22 percent fringe benefit factor, NFER estimated the costs of the engineering studies at $1,010,629.

OSHA views this estimate as unrealistic because NFER assumed that each study must be done separately for each work position in each gin and did not use current salary data assumed are not current. It seems likely and appropriate that the gins, through their association, will be able to cooperate and develop some prototypes of work practices for each work position that will be applicable to the gins, although there may be some due to types and sizes of gins. In some areas, the cooperation of government agencies such as the Agricultural Extension Services, may also be helpful.

In their analysis of financial effects, NFER developed 20 models (four different size classes for each of five regions, to represent the diversity within the industry (Ex. 88e, pp. 4, 5). This would require 60 (20 models in 3 positions) engineering studies. Recalculation of industrial engineering study costs using the NFER figures and increasing assumed salary levels by about 30 percent, results in an estimate of $8,253.

NFER estimated the costs of training supervisors on the assumption that such training would require an hour of time for one supervisor and one engineer for each gin. On that basis, assuming supervisors' wages at $3.98 per hour, NFER estimates supervisor training costs at $36,732. In some localities, cooperation may permit an engineer to train several supervisors from nearby gins. However, the economics may not be significant if supervisor travel time is substituted for engineers' instruction time. Therefore recalculation is appropriate largely to reflect more current wage rates ($7/hour for engineers and $4.80/hr. for supervisors) and numbers of gins, giving a total cost of $40,424.

Costs of employee training discussed by NFER assumed that training will take 10 minutes by the supervisor and that no allowance is made for productivity loss. However, the calculation of costs of training of new employees suggests that an hour of time for those employees was assumed; the costs of training new employees were estimated at $105,036 a year for 14 employees per gin. In addition, NFER estimates costs of training of gin workers at $107,279; no breakdown of this amount is included in the NFER report, but this is assumed to be for the first year only.

If on-the-job training costs specifically for this regulation are recalculated, using 10 minutes of supervisor time and including the same amount of employee time as the basis estimates, productivity loss for such training would be included in the costs. For 2,808 gins, each hiring 21 new or continuing employees a season, there would be 58,968 training sessions in the first year if individual training is required. In the first and ensuing years, if 4 employees per gin are assumed to be continuing workers, such sessions would be required for 17 workers in each of 2,808 gins, or at the rate of 47,736 training sessions a year. Such costs would then be a total of $16,928 for continuing employees and $70,458 for recurring years.

The recalculated estimates are substantially lower than those of NFER but they reflect more current wage rates and number of gins. If there is a bias, it is likely to be on the high side because in many cases employee training may involve several workers in one session, thereby economizing on supervisors' time.

In summary, the NFER industry total for first year costs at $1,251,916 and the RTI estimate of $1 million, are nearly 10 times the estimate of the OSHA recalculation of $135,713. The principal differences are in the assumptions on cooperation in engineering studies and in employee training as well as in the number of gins used as the basis for estimation. NFER first year costs average $384 per gin, while the OSHA estimate is for $48 for first year costs per gin. Recurring annual costs are estimated by NFER at $105,036 for training new employees, or an average of $32 per gin. The OSHA recalculation estimates the industry total at $70,458, or $25 a year per gin for these recurring annual costs.

Informing Employees

The regulation requires that workers be informed of the hazards of exposure to cotton dust. NFER notes that employees can be so informed during other training programs or by supervisors, so that the added cost of this requirement is not considered significant. (Ex. 88e, p. 35) OSHA concurs with this view.

Posting

The regulation requires posting warning signs at entrances to and in each workplace where cotton dust exposure is expected. RTI and NFER assumed the costs per sign to be $4 each. The final regulation requires that, where appropriate, bilingual signs be used. This is not likely to affect the cost per sign. NFER estimates cost of posting on the basis of 6 signs per gin (3 entrances and 3 work areas) for 3,262 gins at $78,288. Costs for 2,808 gins would be $67,392 under the same assumptions. These would be first year costs of $24 per gin. Recurring annual costs for occasional replacement of signs would not be significant.

Recordkeeping

Both RTI and NFER reported jointly the costs of monitoring and recordkeeping requirements of the proposed regulation. However, in the absence of a permissible exposure limit, the final regulation does not require the gins to monitor cotton dust levels periodically. Costs of keeping records for most of the other provisions are included in the costs of performing specific functions, such as medical surveillance examinations, or are incidental to normal maintenance of other records, such as those concerning employment and wages. While such costs are not expected to be significant for each gin, it does seem appropriate to assign some value to the extra effort required. Since NFER anticipated monitoring sample costs at $35 per sample per gin, including recordkeeping costs, a reasonable estimate of the extra costs per gin for recordkeeping might be $35 in the absence of payment for monitoring services. That amount for each of 2,808 gins would add $98,280 to annual costs of the regulation.

Total Costs—Summary

The total costs of compliance for the final regulation are estimated to be a small fraction of the estimated costs of the proposed regulation. As shown in Table 1, the OSHA estimate of total costs of the final regulation is

$1,850,213 for the first year and $1,717,566 for ensuing years for the 2,808 gins expected to remain in operation. This is an average of $659 per gin for the first year and $612 annually for ensuing years, or 15 to 16 cents for each 480-pound bale ginned. OSHA does not consider these costs to be significant.

TABLE 1

	RTI	NFER	OSHA
Monitoring & Recordkeeping	3.5 million/yr	1.7 million/yr.	98,280 (recordkeeping only).
Workpractices	1 million	1.3 million	135,713.
			70,458.
Respirators	2.7 million 1st yr .1 recurring annual.	2.1 million 1st yr 1.6 recurring annual.	275,115 (single use).
Medical Surveillance	2.6 capital	2.4 capital	1,213,714.
	-.8 annual	-.7 1st yr.	
		-.5 annual thereafter	
Signs	28,000	78,000	67,392.
Totals	9,828,000	7,578,000	1,850,213 1st yr.
	1st yr	1st yr	1,717,566 annual.

NFER estimated the costs of attempting to comply with the proposed regulation. The capital costs for engineering controls, estimated at $581,937,000 dominated all other cost estimates. Other capital costs were $2,373,000 for spirometers and $495,000 for reusable respirators. The total capital costs of $584,805,000 constituted nearly 90 percent of first year costs. In addition, the costs of operation and maintenance and energy for the proposed engineering controls at $60,669,000 and the annualized cost of capital at $11,910,000 together constituted nearly 98 percent of the NFER estimate of annualized costs.

While the elimination of requirements for engineering controls in the final regulation had the most substantial cost reducing effects, there are two other significant differences between the proposed and final standards. Again, because there is no specific permissible exposure limit in the final standard, there are no requirements for monitoring. The costs of the monitoring requirements envisioned by the proposed regulation, were estimated by NFER at $1,712,000 a year and by RTI at 3.5 million per year, including recordkeeping. OSHA's recalculation indicates $98,280 as an estimate of record keeping costs attributable to the regulation in the absence of monitoring. Another cost reducing change is that, in the final regulation, use of disposable respirators is permitted. As a result, though daily replacement of disposable respirators for each worker may cost more than daily replacement of filters for reusable respirators, the capital and maintenance expenditures for reusable respirators are avoided. Thus the NFER estimate of annual costs of respirator requirements of the proposed regulation, $1,582,000, and RTI's estimate of 2.7 million were much greater than the $275,115 OSHA estimate to meet the needs of affected workers under the final regulation.

Only in the final regulation's provisions for medical surveillance are costs expected to be higher than those estimated for the proposed standard. The final regulation requires two sets of medical examinations, retesting and counseling, rather than one. Program costs would not double because more than half of those hired are likely to quit before being subject to the second examination and because tests taken for one employer need not be repeated by another. However, the OSHA estimate of medical program costs, at $1,213,714 a year, is more than double the NFER estimate of $467,000 and approximately fifty percent more than RTI's estimate of .8 million in annual costs because the OSHA estimate relates to more workers for the initial examination and includes annualized capital (spirometer) and training costs.

For the final regulation the medical surveillance program accounts for more than two-thirds of the costs, and the respirator program accounts for nearly half of the remainder.

LABOR

Most of the costs of compliance are directly related to worker protection from the hazards of cotton dust. At $612 a year for the average gin in continuing annual costs, or at 15¢ a bale, to be passed on (back) to the cotton grower, the costs of the final regulation are not burdensome, especially as compared to the NFER and RTI estimates of costs of the proposed standard.

OTHER ECONOMIC IMPACTS

RTI and NFER both dealt with the anticipated economic effects of the proposed regulation. These were reviewed in the preamble for the general regulation of cottondust (draft, pp. 62-83). NFER also analyzed the effects of the proposed regulation, but the NFER review dealt primarily with the anticipated impact of the costs of compliance upon financial profiles of a number of models of gin. In the sections below there is an attempt to follow the RTI outline of economic effects, with reference to the NFER conclusions where such reference is relevant and appropriate. In general, under either RTI and NFER analysis, the effects of the final cotton dust regulations for ginning are not significant.

Most of the additional production labor which RTI estimated would be required under the proposed standard were required for the operation and maintenance of engineering controls. However, as noted above, the final standard does not specify a permissible exposure limit, nor use of engineering controls. Therefore most of the additional labor anticipated for the provisions of the proposed regulation will not be required.

Additional labor requirements will be largely for the medical surveillance program. Lost work time for production workers as well as professional time of those administering tests are estimated as the costs of the additional labor. For the seasonal production workers, no significant impact of the marginal numbers of hours involved is anticipated; these hours are likely to be spent by the same workers ordinarily hired by gins, so that no noticeable effect on the local labor supply is likely to occur. For the professional and paraprofessional personnel required for the tests, there may be some temporary labor supply problems. However, if examinations are provided through use of contracted services that can serve a number of gins in a region, few persons will be required in each region. That is one way

OSHA foresees private sector organization will meet the requirements of the medical surveillance program, perhaps in conjunction with other health services programs in those areas. Any shortage is expected to be temporary because the numbers of extra persons required for each region and season are likely to be low. As a result, no significant effect on wage levels for such personnel is expected.

ENERGY

The preamble to the general cotton dust regulation (pp. 64–65), expected changes in energy consumption as a result of two types of effects: firstly, to the extent that increased costs of cotton production led to substitution of synthetic for cotton fibers, the petroleum sources of the synthetic fibers would be the equivalent of increased energy use; secondly, substantial amounts of energy were to be required in the mandated use of engineering controls for the attempt to reach a permissible exposure limit.

For the final regulation on cotton gins, however, OSHA does not anticipate any significant change in energy use. The total cost of the cotton dust regulation on gins, 15–16 cents per bale, is not likely to induce any fiber substitution. As noted above, much of that cost impact is expected to be shifted forward in the price of exported cotton, and the amount to be shifted to domestic textile users is not likely to be significant in comparison to any anticipations of increases in coal or petroleum prices and, consequently, in synthetic fiber prices. Moreover, since the final regulation does not mandate the use of engineering controls in gins, no change in the energy requirements of gins is expected on that account.

CAPITAL REQUIREMENTS, FINANCING

Both RTI and NFER devoted substantial attention to the analysis of capital costs and financing problems associated with the requirements of the proposed standard. The substantial capital requirements of the proposed regulation as estimated by both RTI and NFER gave rise to questions of the ability of gins to qualify for and to obtain financing. However, the final regulation does not require significant capital expenditures by the gins. The principal source of capital spending was the proposed requirement for engineering controls; this does not exist in the final regulation. Others were for monitoring equipment and reusable respirators, and these are not mandated by the final regulation. The only situations where capital expenditures are anticipated are for those gins who have to buy a sirormeter, at $727.50, and this would be the case only where they would not be able to obtain medical examinations through an outside, contracted service. The absence of significant capital expenditures indicates that the gins will not need to compete for funds in capital markets.

BENEFITS

OSHA policy and conclusions on benefit assessment are described in the preamble to the cotton dust regulation for other sectors. In the absence of current, directly relevant epidemiological studies, it is not possible to estimate anticipated declines in the incidence of byssinosis that would result from implementation of the provisions of the final regulation of cotton dust in gins. OSHA is confident that significant worker protection will result from mandated changes in work practices and from medical surveillance and respirator programs. Pending the result of further NIOSH study, more costly controls do not appear to be warranted. The estimated costs of the final regulation of cotton dust in gins are modest when compared to those estimated for the proposed regulation, and OSHA feels that the anticipated benefits in terms of improved worker health will fully justify such costs.

Based upon the foregoing and the record as a whole, OSHA finds that compliance with the standard is well within the financial capability of the ginning industry. Moreover, although the benefits of the standard cannot rationally be quantified in dollars, OSHA has given careful consideration to the question of whether these costs are justified in light of the hazards of exposure to cotton dust. OSHA concludes that these costs are minimal and necessary in order to effectuate the statutory purpose of the Act and to adequately protect employees from the hazards of exposure to cotton dust.

V. SUMMARY AND EXPLANATION OF THE STANDARD

The following sections discuss the individual requirements imposed by the standard for the protection of employees exposed to cotton dust in cotton gins. Each section includes an analysis of the record evidence, the recommendations of NIOSH, and the policy considerations underpinning the decisions on the particular provisions of the standard. Although this ginning standard has been severed from the standard regulating cotton dust exposure in other segments of the textile industry and in non-textile operations (29 CFR 1910.1043), many provisions of both standards are derived from the same data sources. Much of the information presented in the NIOSH criteria document, the preamble to the proposed standard for cotton dust, and elicited as comment and testimony during the rulemaking proceeding is equally pertinent to the development of this ginning standard. Accordingly, the rationale for many provisions in this ginning standard, such as medical surveillance and respirators, is parallel to the rationale for the comparable provisions in the general cotton dust standard. The discussion of those provisions in the preamble to 29 CFR 1910.1043 is referenced herein and not repeated detail.

(a) *Scope and Application.* This standard applies to all cotton gins. Although the standard is promulgated as a general industry standard, it has also been incorporated in 29 CFR Part 1928 as a standard applicable to agricultural operations. This ginning standard applies, therefore, to cotton gins located on farm sites as well as to cotton gins in other locations; it applies whether the gins are considered general industry or agricultural operations.

Several provisions of the standard will be effective September 4, 1978, whereas others will not be effective until September 4, 1979. Only the requirements for work practices, training, use of respirators during maintenance and repair and "blow down," and posting of signs will have to be implemented for this year's ginning season. The requirements for medical surveillance and respirators for employees who are at an increased risk from exposure to cotton dust, will not have to be implemented until the 1979 ginning season. OSHA's decision to delay for a year implementation of these medical surveillance and respirator requirements is based on its determination that the ginning industry, as a whole, will be unable to comply with these requirements in time for this year's ginning season. The ginning industry consists primarily of numerous small to moderate sized gins located in rural areas. As pointed out below, there is a question as to the availability of adequate numbers of physicians and other trained health specialists in these areas, and there will, consequently, be a need for these gin employers to develop means of obtaining the services necessary to provide the required medical surveillance for their employees. Since the determination that an employee is at an increased risk from exposure to cotton dust cannot be made before the initial medical examination of that employee, compliance with the requirement of the standard that such employee be furnished a respirator also cannot be undertaken until the 1979 ginning season.

(b) *Definitions.* The standard contains four definitions which remain unchanged from those of the proposal. The definition of "cotton dust" is discussed in detail in the preamble to 29 CFR 1910.1043 which regulates exposure to cotton dust in the textile and non-textile industries.

(c) *Methods of Compliance.* The proposed standard would have required engineering controls along with work practices as the preferred means of reducing dust concentrations in cotton gins below a specified permissible exposure limit and would have allowed the use of respirators only where such controls were infeasible or inadequate to reach the specified level. The final standard, however, sets no numerical permissible exposure limit, but rather requires work practices to reduce employee exposure. As indicated earlier, the changes in the proposed methods of compliance are a result of OSHA's decision not to establish a permissible exposure level for cotton gins and OSHA's determination that work practices, coupled with medical surveillance and other compliance requirements, will provide adequate protection to gin employees against the hazards of exposure to cotton dust.

(d) *Work Practices.* The final standard requires employers to establish and implement a written program of work practices which will reduce cotton dust exposure in each specific job. This requirement essentially replaces the proposed requirement for a written compliance program. The standard also prescribes specific work practices which, at a minimum, must be implemented. Since, as earlier indicated, the higher the level of exposure to cotton dust, the greater the health risk, work practices are necessary to reduce employee exposure and thus reduce the risk. Evidence in the rulemaking record established that work practices are important in reducing employee exposure in the cotton industry (See the discussion the *Work practices* in the preamble to 29 CFR 1910.1043). Considerable testimony supported the need for establishment of work practice programs in the cotton industry (Ex. 17, p. 4, 5–7; Ex 38; Ex. 1, p. 98; Ex. 16 p. IV–30). OSHA concludes that this evidence and testimony also support the usefulness of work practice programs in cotton gins. Since there are only three basic work areas in the gin (yard and suction, conditioning and ginning, and bale packaging, Ex. 88C, p. 2) and only a few distinct job functions, developing a work practice program should not be unduly burdensome.

The lack of a permissible exposure limit has a broad impact on work practice controls in gins. With no mandatory requirement for engineering controls, work practices are accorded greater significance as a worker protection strategy. Testimony presented by witnesses familiar with ginning supports the need for and importance of housekeeping and maintenance in reducing dust in gins (TR 901; Ex. 88, Minutes of National Ginners Technical Committee Meeting, pp. 5–8). Since intact gin machinery, relying on suction and gravity to move cotton, will by its nature contain dust, maintaining the integrity of duct work, sleeves, joints, and other components of the system, including machinery used for dust control, ventilation and production, will reduce dust dispersal.

Accordingly, the standard requires the employer to develop basic housekeeping provisions to maintain surfaces as free as practicable of accumulations of cotton dust. The standard also requires the employer to inspect, clean, maintain, and repair all gin engineering equipment and ventilation systems including power sources, ducts and filtration units pursuant to a detailed written program. Testimony presented during the hearings indicated that significant improvements in reduction of cotton dust levels in gins could be achieved by simply maximizing the effectiveness of gin machinery (TR 901; Ex. 88, Minutes of National Ginners Technical Committee Meeting, p. 5, 8). The employer would have to, at a minimum, tape or cover leaks in valves, flashing, elbows, and bands on air lines.

The gin standard requires that cotton and cotton waste shall be stacked, sorted, baled, dumped, removed, or otherwise handled by mechanical means except where the employer can show that it is infeasible to do so. Although much of the handling of cotton in many gins, especially the modern ones, is accomplished by automatic or enclosed systems, there are gins where these operations are performed manually. OSHA recognizes that in certain operations, substitutes for personal handling do not presently exist, for example, where cotton is sucked out of a trailer, or where the ginner routinely handles the cotton to aid in judging its condition, or handles cotton under emergency conditions, such as a fire or clog in the mechanisms (Ex. 88F, p. 12). The standard recognizes that where mechanical means are infeasible, the employers may select another method provided that it is the method which most effectively prevents or reduces employee exposure to cotton dust, thereby ensuring that the greatest protection is afforded to employee in such operations. Therefore, the infeasibility of mechanical means in certain operations does not detract from OSHA's position that employee handling of cotton or cotton waste products should be eliminated to the extent feasible. (Ex. 2) Therefore, those work practices and procedures which afford the most protection and which are feasible must be utilized to control employee exposure.

Housekeeping and maintenance activities cannot be wholly effective unless they are systematically and regularly done. Therefore, the standard requires the employer to develop a written plan which lists appropriate schedules for carrying out the housekeeping and maintenance operations mandated by this standard for minimizing worker exposure to cotton dust.

A number of specific work practices are also required. The standard prohibits the employer from using compressed air cleaning in "blow down" operations except where alternative means are not available. There was only limited comment on this provision by participants, who particularly addressed the issue of whether there should be a blanket prohibition of "blow down". In opposition to a prohibition of "blow down", one commenter mentioned the fire hazard posed by accumulation of fine particles (Ex. 88E, p. 7), and another raised by the safety hazard created when workers are forced to vacuum rafters and ceiling ducts (Ex. 88F, p. 13). OSHA agrees that, in view of the negative safety implications, "blow down" must be allowed where alternative means of cleaning are infeasible. OSHA has required that respirators be worn by workers performing the "blow down" and that other workers be required to leave the area during this cleaning operation.

The final standard also requires the implementation of specific housekeeping provisions, including floor sweeping with a vacuum or a method designed to reduce dispersal of dust. Testimony in the record supports the usefulness of housekeeping in reducing the levels in gins (Ex. 88, Minutes of National Ginners Technical Committee Meeting, Neitzel, p. 8). OSHA, in the preamble to 29 CFR 1910.1043, states that it accepts push-brooms or plows as a "method designed to reduce dispersal of dust," in the cotton textile industry and in non-textile industries. Furthermore, the injection of floor sweepings into a trash line could serve to remove a dust source from a work area (Ex. 88, Minutes * * *, Prikosovits, p. 60).

Some participants argued that implementation of work practices would result in lost productivity (Tr. 867). The discussion of lost productivity in the preamble to the cotton industry standard makes two points which apply equally to the issue in ginning. First, there is no evidence offered in support of claims that productivity will suffer because of the implementation of work practice controls. Second, there is testimony that certain work practices should have no effect on productivity or may indeed increase efficiency. For example, it is generally accepted that maintenance and repair of ventilation and production equipment will lead to increased efficiency. The record also demonstrates that inefficiency exists in the use of gin labor, apart from any effect expected from this standard (Ex. 88, Extract from

the Agricultural Handling and Processing Industry, USDA). OSHA anticipates that the implementation of work practice controls in the context of developing improved labor performance could lead to overall gains in productivity (Ex. 88, Extract * * *, p. 10).

(E) RESPIRATORY PROTECTION

The standard contains requirements for respiratory protection. Although the specific requirements for respiratory protection applicable to the ginning industry differ somewhat from the requirements applicable to general industry, OSHA is relying on the evidence elicited on respirators for the cotton industry and on its own expertise in formulating the ginning provisions. In gins, as in other workplaces, respirators cannot be considered to be the primary means of employee protection since respirators have many limitations which make them undesirable. One problem, described by several gin owners, is the refusal of the majority of workers to use respirators when these devices have been made available (Tr. 878, Tr. 3850; Ex. 105). Nevertheless, OSHA has concluded that respirators must be made available and their use required under certain circumstances. Support for respirator usuage during ginning operations is found in the testimony of the North Carolina Department of Agriculture (Ex. 107a, p. 8) and of David Smith, on behalf of the National Cotton Ginners Association (Ex. 88F, pp. 13–16). OSHA also notes testimony in the record showing that gin workers will wear respirators when dust levels are heavy (Ex. 105 e–1) or when the nature of the job (e.g. cleaning a lint filter) produces high dust exposure (Ex. 105 m).

The absence of a permissible exposure limit in this standard has two major effects on this provision for respiratory protection: (1) The use of respirators becomes a major mode for reducing dust exposure, and (2) all respirators are equally acceptable.

The employer is required to provide and assure the wearing of respirators by all exposed workers who manifest significant sensitivity to cotton dust as determined by medical surveillance. OSHA has provided the supervising physician with recommended criteria with which to determine whether a respirator should be required (Appendix A). Respirators have been shown to be effective in suppressing the symptoms of exposure to cotton dust in affected workers (Tr. 1665, 1679). The standard provides that where respirators are required under the provisions of the medical surveillance program, the employer shall provide a powered air purifying respirator for each employee who expresses a preference for such a device. As the preamble to the proposal stated, "the wearing of a non-powered respirator may be difficult for medical reasons, e.g. reduced pulmonary function or chronic lung disease," (41 FR 56506) Since there are no objective medical tests to determine an employee's ability to wear a negative pressure or demand type respirator, the determination must be left to the subjective evaluation of the employee.

The standard further requires the employer to assure use of respirators during maintenance operations such as "blow-down". OSHA recognizes that the worker is subject to excessive exposure to cotton dust during these operations, and requires the wearing of respirators during dusty operations even when engineering controls are in place to reduce general environmental dust limits (Ex. 107a, p. 8). Therefore OSHA requires that employees engaged in "blow down" wear respirators.

The standard also requires the employer to notify his employees of the availability of respirators and to provide a respirator to any employee requesting one. OSHA believes the respirator requirements do not place any undue burden on the employer indeed, some gin owners already furnish employees with respirators (Tr. 878; Tr. 3850; Ex. 105 e–1). OSHA is of the view that this requirement will protect workers who are at an increased risk but who have not yet been detected through medical surveillance, or who are reluctant to admit to subjective symptoms or who perceive that they have a temporary need for respiratory protection.

The protection factor upon which respirators are usually rated cannot be used as a basis for selecting respirators for use in gins since an exposure limit does not provide the necessary yard stick. Consequently, the respirator provision for the ginning industry contains the following changes from the proposed standard: (1) All NIOSH approved respirators are acceptable, including single use respirators; (2) the respirator table is dropped from the standard; (3) no specific qualitative or quantitative fit testing is required.

In allowing the use of any NIOSH approved respirators OSHA has given serious consideration to the question of whether adequate protection against the hazards of cotton dust exposure would be afforded gin employees. OSHA recognizes that single use (disposable) respirators have the lowest protection factor and that employers, on the basis of cost, may provide their employees only with single use respirators. As pointed out in greater detail in the Respirator Section of the accompanying standard, however, even the single use respirator has been shown to be help in reducing dust exposure and suppressing the effects of cotton dust. Moreover, it appears in general that employees prefer to use the lighter weight respirators because they are more comfortable. Wearer acceptance is most critical to the success of any respirator program and of increased importance in the context of gins since the standard requires the employer to provide a respirator to any employee who requests one. For the foregoing reasons, OSHA has concluded that allowing the use of any NIOSH approved respirator is appropriate.

While some workers may have difficulties with the wearing of respirators, these difficulties would be mitigated by the fact that, as earlier indicated, a gin worker spends half of his work period in the outside environment where the respirator could be removed. However, even though workers find relief through excursions into the fresh air, skin irritation can still result from the accumulation of dust around the facepiece seal. To prevent this irritation and to minimize the discomfort of respirator use, the standard requires that employees be allowed to periodically wash their faces and respirator facepieces, in order to remove any accumulation of dust.

While it is known that worker resistance to wearing respirators can be great, much can also be done to eliminate this problem (Tr. 3042; 4180–1). The employee must be properly trained to wear the respirator, to know why the respirator is needed, and to understand the limitations of the respirator. An understanding of the hazard involved is necessary to enable employees to take steps necessary for their own protection.

The standard further requires that the employer institute a respiratory protection program in accordance with 29 CFR 1910.134. That standard contains basic requirements for proper selection, use, cleaning, and maintenance of respirators.

The standard requires the employer to provide respirators for protection from exposure to cotton dust "at no cost to the employee". OSHA has allocated the costs of respirators required for protection from exposure to the employer in order to effectuate the purposes of the Act. The employer will be in the best position to provide the correct type of equipment and keep it in repair. The employers' costs in providing respirators were considered in the economic assessment. This language in the standard makes explicit the position which has long been implicit in all OSHA health standard proceedings under section 6(b) of the Act.

(F) MEDICAL SURVEILLANCE

The standard requires each employer to institute a medical surveillance program for all gin employees exposed to cotton dust. The need for a medical

surveillance program in all workplaces and the evidence supporting diagnostic procedures set forth in the standard were presented in great detail in the Medical Surveillance section of the preamble to 29 CFR 1910.1043, Occupational Exposure to Cotton Dust. The need for medical surveillance in gins is increased by the absence of an environmental exposure level in the cotton dust standard applicable to ginning, and the consequent reliance upon screening to identify and aid acute reactors.

The standard provides for administration of a standard respiratory questionnaire (Appendix B Sp II) or Spanish questionnaire (Appendix B IV) for Spanish speaking workers prior to each ginning season. The standard also requires pulmonary function measurements including FVC and FEV_1 to be performed at the time of initial assignment, before each employee enters the operating gin. This requirement provides for an initial assessment of each employee's fitness for exposure to cotton dust and establishes a baseline health condition against which changes in an employee's health may be compared. The spirometry testing must be repeated during the ginning season, after at least 14 days of employment and before the termination of employment for the season. The measurements must be performed before the employee enters the gin on the first day of work following at least 24 hours or one working day away from work. The pulmonary function testing must be repeated during the shift as specified in section (e)(3) of the standard. The purpose of retesting during the ginning season is to detect acute response to cotton dust among gin workers. If an employee changes his job and goes to another gin during the season, the second employer will not be required to provide medical testing already completed at a previous workplace, provided that prior administration of medical surveillance is demonstrated through transfer of the testing results. The standard also requires that the employer provide each affected employee with an opportunity for medical examination and pulmonary function testing on an annual basis.

The framework for medical surveillance in gins is generally the same as that applied in the cotton industry. 29 CFR 1910.1043. There was little testimony of substance concerning the implementation of medical surveillance in the ginning industry because of the general posture of many industry participants that such a program was unnecessary and infeasible (Ex. 107a; Ex. 88a, p. 8). Upon reviewing all the evidence in the record, OSHA concludes that medical surveillance is of critical importance to thousands of exposed gin workers. OSHA relies on the evidence in Health Effects to support this conclusion.

The question of "feasibility" is more complex. Several arguments against the feasibility of medical surveillance requirements were made during the cotton dust hearing. The first argument is basically logistical: the ginning industry consists of numerous small to moderate sized gins often separated from each other and from hospitals or medical practitioners by substantial distances (Ex. 88c; Ex. 88f; Tr. 5051). In any one cotton growing region, many gins might be starting up simultaneously (Tr. 3850; Tr. 5051). During the course of the season, each gin could expect to acquire and lose some workers through turnover (Tr. 4007-8). Finally, many ginners and their representatives complained that the preplacement requirement and the follow-up examination would disrupt gin routines (Tr. 867). They argued that, not only might testing be disruptive, but it would be unduly costly, especially if charges for local diagnostic services were separately applied to each gin hire (Tr. 971-3; Tr. 3928).

Upon reviewing the testimony on medical surveillance in gins and in the cotton industry at large, OSHA has concluded, contrary to the contentions of the ginning industry, that medical surveillance as outlined in this final standard is feasible. While testimony has identified several obstacles to be overcome, there is no basis for the overwhelming pessimism of the industry. Claims of total infeasibility must be viewed against a record devoid of any evidence indicating any attempt by the industry to establish a medical screening program. In contrast to the lack of interest of the industry as a whole or any individual ginner, Palmer and his NIOSH team were successful in implementing a prototypical medical surveillance program during their study in Texas and New Mexico (Ex. 2, No. 59; Ex. 18). The basic structure of Palmer's screening program is incorporated in the provisions of this standard.

The proposed provisions which the industry found to be infeasible have also been changed in the final standard to facilitate implementation by ginners. First, the content of the screening programs has been altered to permit pulmonary function measurements after one working day or 24 hours in order to fit into a typical gin worker's work schedule or to follow a brief shut-down (Ex. 88, p. 2). The subjective part a Spanish version of the questionnaire where a language barrier could be an impediment to an expeditious administration (Tr. 758-9; Ex. 88f, p. 6). OSHA also relies on testimony indicating the relative ease and simplicity of the few basic means of the required medical surveillance. For example, an experienced technician can secure satisfactory tracings on the subject in about 8-10 minutes. Calculations of FVC and FEV_1 are simple and on some instruments could be read directly from the chart. The cost, size and the ease of handling of the spirometers depend on the needs and resources of the people using the equipment. Although there are expensive, computerized, non-portable units used mainly in research, there are portable, reliable and inexpensive spirometers on the market which meet minimum spirometry standards. These portable units can be used to conduct tests required by the standard.

Secondly, while the standard requires each medical surveillance program to be under the supervision of a physician, the standard permits the use of nurses, health professionals, and appropriately trained technicians in place of physicians in the implementation of the standard. Once personnel has been properly trained, they can provide the on-site administration of medical surveillance without any sacrifice in protection afforded the gin employee. Minimum training requirements are established as part of this standard to assure quality of testing.

Thirdly, the standard takes turnover into consideration by allowing employers to co-ordinate medical surveillance over the course of the ginning season. Thus, if an employee has been provided with a baseline examination before moving to another gin, the second employer need only provide the retest. Any employer hiring the individual during the remainder of the season will not be required to screen him.

Furthermore, OSHA envisions the employment of other resources in the implementation of the standard. For example, in the case of gin employers located too far from cities, joint action can solve individual problems. Vans similar to that used by Palmer, containing some basic, easily obtainable equipment, is one obvious suggestion. Co-operative action would further serve to reduce the per-patient charge beyond that estimated on the basis of single diagnostic examinations. There is some evidence of availability of such services at present (Tr. 3926, 3928). OSHA is hopeful that the United States Department of Agriculture which offered its cooperation during the hearing will also be instrumental in developing viable solutions to the problems of individual gin owners faced with the need to find proper medical services (Ex. 92d, p. 13-14). For example, the Agricultural Extension Service might disseminate information which could facilitate implementation of the standard.

For all these reasons, OSHA believes that medical surveillance is feasible in the cotton ginning industry. This conclusion is grounded on the assumption

that the members of the industry will make a good faith effort to use all resources available to them. Even if in the case of individual gins or specific localities for which implementation of medical surveillance may be difficult, the Agency is compelled by the health evidence in the record to require employers to undertake the efforts necessary to comply. Medical surveillance has a dual purpose in the framework of the standard: not only does it serve to identify susceptible workers, but it triggers the use of respirators which protect employees against the hazard of cotton dust.

(g) EMPLOYEE EDUCATION AND TRAINING

The final standard for ginning requires each employer to provide each employee with access to this regulation and to inform each employee of the specific nature of operations which could result in exposure to cotton dust. The employer is also responsible for providing employee training programs which would include information on mandated work practices, respirators, and medical surveillance as well as the signs and symptoms of respiratory diseases, and a review of the entire standard.

Scant testimony on education and training provisions applied to ginning was introduced into the hearing record (Ex. 88F, pp. 17-18). Nevertheless, OSHA views the reasoning supporting employee education and training in other areas of the cotton industry as equally applicable in the ginning industry. As stated in the proposal, information and training are essential for the protection of employees because employees can do much to protect themselves if they are made aware of the hazards in the workplace. This is especially true in ginning where the standard relies on respirators, work practices and in particular, medical surveillance provisions, to afford worker protection. The need for worker understanding of and cooperation in the implementation of these protection programs is well grounded in logic and documented in the record. There is also evidence that, in the past, workers have not been informed of the hazards in the workplace or the purpose of medical surveillance and respirators even when these programs have been established.

OSHA believes that a medical surveillance program, especially one which can be waived by employees, cannot be wholly effective unless workers understand the nature of the disease and its continuing hazard. This standard's reliance upon medical surveillance as a primary means of identifying and protecting sensitive workers makes imperative worker understanding and acceptance of the program's purpose and goals. Since a significant percentage of the local and the migrant labor pool in the Southwest and West communicate in Spanish rather than English (e.g., Tr. 3910; Tr. 3747; Tr. 3752), the standard provides for bilingual education and training (Ex. 88F, pp. 5-6). Any employer whose workforce consists of a significant percentage of Spanish speaking workers who cannot communicate effectively in English must provide bi-lingual administration of the provisions of this section. In setting this requirement, OSHA recognizes that some gins already provide instructions in Spanish, both oral and written, for the benefit of gin work crews. Consequently, the requirements of this provision do not appear, on the basis of the evidence in the record, to be infeasible or unduly burdensome for the gins employing a significant percentage of Spanish-speaking workers.

The evidence for the general cotton industry also supports the requirement, applied by this standard to the ginning segment of the industry, that employers post the regulation and its appendices in the workplace at a public location which is readily accessible to the employee, in addition to making copies available to employees upon request. One participant suggested that workers can be easily intimidated if they must request the material from a company supervisor. Moreover, once identified, a worker might be fearful of taking steps with regard to non-compliance, such as requesting an OSHA inspection. OSHA is aware of worker fears referred to in connection with Dr. Alan Palmer's study and testimony (Tr. 789-91, 806). Further, OSHA believes that worker fears of repercussions when exercising rights under the regulations, whether real or imagined, would diminish worker participation in implementing the standard. On the other hand, the posting requirement resolves worker concerns without adding any burden to the employer.

As in the case of the general cotton dust standard, OSHA considered the recommendation of several participants that OSHA provide materials and a uniform format for employee education and training. For the reasons set forth in the preamble to 29 CFR 1910.1043, OSHA has not adopted this provision in full. However, OSHA has included in the ginning standard, as in 29 CFR 1910.1043, a requirement that employers include as part of their training programs and distribute to employees any materials, relating to the Occupational Safety and Health Act, the regulations issued pursuant to that Act, and to this ginning standard, which are made available by OSHA.

(h) SIGNS

The final standard requires that warning signs be posted at gins at employee entrances. The standard specifies the legend for these signs. The purpose of the sign is to warn employees that they are entering an area where there is cotton dust exposure which may cause byssinosis.

The proposal would only have required signs where respirators were mandated. However, during the course of the hearing the need for these additional posting provisions was clearly demonstrated. The reasons supporting the usefulness of signs in cotton mills apply equally persuasively to cotton gins (Tr. 3052).

OSHA believes that it is important, and indeed section 6(b)(7) of the Act requires, that appropriate forms of warning, as necessary, be used to apprise employees of the hazards to which they are exposed in the course of their employment. OSHA believes as a matter of policy, that employees should be given the opportunity to make informed decisions on whether to work at a job under the particular working conditions existent. Furthermore, OSHA believes that when the control of potential safety and health problems involves the cooperation of employees, the success of such a program is highly dependent upon the worker's understanding of the hazards attendant to that job.

In light of the serious nature of the hazard of exposure to cotton dust, OSHA does not believe that periodic training alone will adequately apprise employees of the hazard. However, coupled with the training requirements, OSHA believes that the requirement to post signs will adequately do so. Accordingly, the standard requires gin employers to post warning signs.

As recommended in the criteria document the standard requires that warning signs be printed both in English and in Spanish if the workforce consists of a significant percentage of Spanish-speaking employees. OSHA is aware that warning signs are customarily printed in Spanish in gins located in the Southwest and West.

(i) RECORDKEEPING

OSHA considers it necessary that cotton gin employers retain records of medical surveillance. The purpose of those records is, both to assure the employer's compliance with the medical surveillance requirements, and to collect data vital to epidemiological and diagnostic investigations. Additionally, medical surveillance records make the gin employer aware of the incidence of respiratory effects in his establishment, assist him to focus on such aspects of his operations which may materially impair the health of his employees, and identify for him operations where exposure needs to be reduced through implementation of additional or different work practices.

Medical records also assist the employees' examining physicians to accurately diagnose and treat any health problem and assure proper evaluation of their health.

The few adverse comments directed to the recordkeeping provisions in the particular case of ginning complained of the paper work burden the requirement would pose for single gins (Tr. 3994) and small hospitals conducting medical surveillance for gin employers (Tr. 3998). High turnover coupled with the long retention period for transient employees appeared to be the core of this criticism (Ex. 105e-1, p. 6).

OSHA concludes, however, that the advantages of retaining medical records listed above far outweigh the burden to the employer. OSHA's conclusions as to the need for retention of medical records by the cotton industry as a whole are also relevant to the questions raised concerning retention of these records in ginning. As stated in the preamble to 29 CFR 1910.1043, a retention period is necessary in order to develop sufficient longitudinal dose-response data.

Furthermore, OSHA has greatly reduced the paperwork required of employers by limiting recordkeeping to medical records, and reduced the retention period from the proposed 20 years to 10 years. The reduction in the retention period appears to better reflect the average career of a gin worker, and thus to insure the gathering of the necessary data in a shorter period of time.

This final standard, in conformity with other OSHA standards, requires that all records required to be maintained by the standard be made available to the Director and Assistant Secretary, and that medical records be available to a physician or other individual designated by an employee or former employee. More specifically, it is necessary for the Assistant Secretary and Director to have access to records for enforcement and research purposes. The physician needs access to medical records for diagnostic purposes.

The transfer provisions are unchanged, except for the addition that records for research are no longer to be mailed by registered mail for NIOSH at the expiration of the retention period or when the employer ceases to do business. NIOSH is to be notified at the expiration of the retention period so it can determine if the records are still needed for research purposes.

(j) EFFECTIVE DATE

In order to ensure that affected employers and employees will be informed of the existence of the provisions of this standard, and that employers are given an opportunity to familiarize themselves and their employees with the existence of the new requirements, this standard is not effective until September 4, 1978.

Some provisions of the standard have different start-up dates. The medical surveillance requirement of paragraph (e) and the requirement in paragraph (d)(2)(i) for respirators for workers identified as being at an increased risk are effective September 4, 1979. This date has been selected to make it clear that these provisions do not apply for the 1978 ginning season, but apply starting with the 1979 ginning season. Start-up dates for other requirements of the standard are the effective date of the standard for all operating gins.

APPENDICES

Appendices B, C, and D included with this standard are incorporated as a part of this standard and impose additional mandatory obligations on covered employers. Appendices A and E contain recommendations and, therefore, are not intended to create any additional obligations not otherwise imposed or to detract from any existing obligation.

IX. AUTHORITY

This document was prepared under the direction of Eula Bingham, Assistant Secretary of Labor for Occupational Safety and Health, 200 Constitution Ave. NW., Washington, D.C. 20210.

Accordingly, pursuant to sections 6(b) and 8(c) of the Occupational Safety and Health Act of 1970 (84 Stat. 1593, 1599, 29 U.S.C. 655, 657), Secretary of Labor's Order No. 8-76 (41 FR 25059), and 29 CFR Part 1911, Title 29, Code of Federal Regulations, is hereby amended by adding a new § 1910.1046a to Part 1910, and by adding a cross-reference to the new section in § 1928.21 of Part 1928, as set forth below.

In addition, for all reasons discussed above, pursuant to section 6(b)(8) of the Act (84 Stat. 1594: 29 U.S.C. 655), OSHA has determined that this new standard in § 1910.1046a is more effective than the existing national consensus standard in 29 CFR 1910.1000, Table Z-1 and that the new standard will better effectuate the purposes of the Act.

Signed at Washington, D.C., this 16th day of June 1978.

EULA BINGHAM,
Assistant Secretary of Labor.

1. Part 1910 of Title 29 of the Code of Federal Regulations is hereby amended by adding a new § 1910.1046a and Appendices A, B, C, D, and E to read as follows:

§ 1910.1046a Exposure to cotton dust in cotton gins.

(a) *Scope and application.* This section applies to the control of employee exposure to cotton dust in cotton gins.

(b) *Definitions.* For the purpose of this section:

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee;

"Blow down" means the cleaning of equipment and surface with compressed air;

"Cotton dust" means dust present in the air during the handling or processing of cotton which may contain a mixture of many substances including ground-up plant matter, fiber, bacteria, fungi, soil, pesticides, non-cotton plant matter and other contaminants which may have accumulated with the cotton during the growing, harvesting and subsequent processing or storage periods.

"Director" means the Director of the National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health, Education, and Welfare, or designee.

(c) *Work practices.* Each employer shall immediately establish and implement a written program of work practices, which shall minimize cotton dust exposure for each specific job. Where applicable, the following work practices shall be included in the written work practices program:

(1) *General.* (i) All surfaces shall be maintained as free as practicable of accumulations of cotton dust.

(ii) The employer shall inspect, clean, maintain and repair, all engineering control equipment, production equipment and ventilation systems including power sources, ducts, and filtration units of the equipment, and at a minimum, tape or cover leaks in valves, flashing, elbows, and bands on air lines.

(iii) Cotton and cotton waste shall be stacked, sorted, baled, dumped, removed or otherwise handled by mechanical means except where the employer can show that it is infeasible to do so. Where infeasible, the method used for handling cotton and cotton waste shall be the method which most effectively reduces exposure to the lowest level feasible.

(2) *Specific.* (i) Floors and other accessible surfaces contaminated with cotton dust may not be cleaned by the use of compressed air.

(ii) Cleaning of clothing with compressed air is prohibited.

(iii) Floor sweeping shall be performed by a vacuum or with methods designed to minimize dispersal of dust.

(iv) Compressed air "blow-down" cleaning shall be prohibited, except where alternative means are not feasible. Where compressed air "blow-down" is done, respirators shall be worn by the employees performing the "blow-down," and employees in the area whose presence is not required to perform the "blow-down" shall be required to leave the area during this cleaning operation.

(3) *Workpractice plan.* A written workplace plan shall be kept which shall list appropriate schedules for carrying out housekeeping operations, and for cleaning and maintaining dust collection equipment. The plan shall be made available for inspection by the Assistant Secretary.

(d) *Use of Respirators*—(1) *General.* Where the use of respirators is required under this section, the employer shall provide, at no cost to the employee, and assure the use of respirators which comply with the requirements of this paragraph (d).

(2) *Use of respirators.* Respirators shall be used in the following circumstances:

(i) By workers identified by medical surveillance under paragraph (e)(6)(i)(*d*) of this section; or

(ii) During operations such as maintenance and repair activities, in which work practice controls are not feasible; or

(iii) In operations specified under paragraph (c)(2)(iv) of this section.

(3) *Availability upon request.* Respirators shall be made available upon request, to any employee exposed to cotton dust

(4) *Respirator selection.* (i) Where respirators are required under this section, the employer shall select, provide and assure the use of any respirator tested and approved for protection against dust by the National Institute of Occupational Safety and Health (NIOSH) under the provisions of 30 CFR Part 11.

(ii) Where respirators are required by this paragraph, the employer shall provide either any NIOSH approved respirator or at the option of each affected worker, a NIOSH approved powered air purifying respirator with a high efficiency filter.

(5) *Respirator program.* The employer shall institute a respirator program in accordance with § 1910.134 (b), (d), (e), and (f).

(6) *Respirator usage.* (i) The employer shall assure that the respirator used by each employee exhibits minimum facepiece leakage and that the respirator is fitted properly.

(ii) The employer shall allow each employee who uses a filter respirator to change the filter elements whenever an increase in breathing resistance is detected by the employee, and shall maintain an adequate supply of filter elements for this purpose.

(iii) The employer shall allow employees who wear respirators to wash their face and respirator facepiece to prevent skin irritation associated with respirator use.

(e) *Medical surveillance*—(1) *General.* (i) Each employer who has an operating gin in which cotton dust is present shall institute a program of medical surveillance for all employees exposed to cotton dust.

(ii) The employer shall assure that all medical examinations and procedures are performed by or under the supervision of a licensed physician, and are provided without cost to the employee.

(iii) Persons other than licensed physicians, who administer the pulmonary function testing required by this section, shall complete a NIOSH approved training course in spirometry.

(2) *Initial examinations.* For each ginning season, at the time of initial assignment, the employer shall provide each employee who is or may be exposed to cotton dust, with an opportunity for medical surveillance that shall include:

(i) A medical history;

(ii) The standardized questionnaire in Appendix B; and

(iii) A pulmonary function measurement, including a determination of forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1), and the percentage that the measured values of FEV and FVC differ from the predicted values, using the standard tables in Appendix C.

(iv) Based upon the questionnaire results, each employee shall be graded according to Schilling's byssinosis classification system.

(3) *Mid-season retest.* The determinations required under paragraph (e)(2) of this section shall be made again for each employee after at least 14 days of employment and before the termination of employment for the season. The determinations shall be made following at least 24 hours or 1 working day after previous exposure to cotton dust. The pulmonary function tests shall be repeated during the shift, no sooner than 4 and no more than 10 hours after the beginning of the work shift; and, in any event, no more than 1 hour after cessation of exposure.

(4) *Periodic examinations.* (i) The employer shall provide the medical surveillance under this paragraph (e) annually.

(ii) A comparison shall be made between the current examination results and those of previous examinations and a determination made by the physician as to whether there has been a significant change.

(iii) An employee whose FEV_1 is less than 60 percent of the predicted value shall be referred to a physician for a detailed pulmonary examination.

(5) *Information provided to the physician.* The employer shall provide the following information to the examining physician:

(i) A copy of this regulation and its Appendices;

(ii) A description of the affected employee's duties as they relate to the employee's exposure;

(iii) A description of any personal protective equipment used or to be used; and

(iv) Information from previous medical examinations of the affected employee which is not readily available to the examining physician.

(6) *Physician's written opinion.* (i) The employer shall obtain and furnish the employee with a copy of the written opinion from the examining physician containing the following:

(*a*) The results of the medical examination and tests, including any determinations made under paragraph (e)(4)(ii) of this section.

(*b*) The physician's opinion as to whether the employee has any detected medical conditions which would place the employee at increased risk of material impairment of the employee's health from exposure to cotton dust;

(*c*) The physician's recommended limitations upon the employee's exposure to cotton dust or upon the employee's use of respirators;

(*d*) The physician's recommendations for the employee's use of a respirator where dust effects could be suppressed by respirator use;

(*e*) A statement that the employee has been informed by the physician of the results of the medical examination and any medical conditions which require further examination or treatment.

(ii) The written opinion obtained by the employer shall not reveal specific findings or diagnosis unrelated to occupational exposure.

(7) *Spanish speaking employees.* An employer whose workforce consists of a significant percentage of Spanish speaking workers who cannot communicate effectively in English shall provide bi-lingual administration of the medical surveillance requirements, including use of the Spanish questionnaire provided in Appendix B.

(8) *Non-duplication of medical surveillance.* (i) During any one ginning season, an employer is not required to provide medical surveillance as described in this paragraph (f) of this section for any employee who can demonstrate that both the background medical surveillance and the mid-season retest required by paragraph (e) of this section were administered during that ginning season while in the employment of another gin employer.

(ii) If an employee can demonstrate that the background medical surveillance has been administered but not the mid-season retest, the employer shall provide the mid-season medical retest of paragraph (e)(3) of this section, and comply with provisions of paragraphs (e)(4)–(e)(6) of this section. Where the employer is administering only the mid-season retest, the employer shall provide the mid-season retest after at least 14 days of employment in his gin and before termination of employment for the season.

(iii) For purposes of this section, where the employer does not adminis-

ter any medical surveillance, the employer shall be satisfied that an employee has undergone the medical surveillance required under paragraphs (e)(1) to (e)(3) of this section upon receipt of written notification from the employer who administered the test, or upon receipt by the physician supervising the program, of a copy of the results of medical surveillance.

(f) *Employee education and training.*—(1) *Training program.* (i) Each employer who operates an active gin shall institute a training program for all his employees, prior to initial assignment, and shall assure that each employee is informed of the following:

(*a*) The specific nature of the operations which could result in exposure to cotton dust;

(*b*) The measures, including work practices, required by paragraph (c) of this section, necessary to protect the employee from excess exposures;

(*c*) The purpose, proper use and limitations of respirators required by paragraph (d) of this section;

(*d*) The purpose for and a description of the medical surveillance program required by paragraph (e) of this section: and other information which will aid exposed employees in understanding the hazards of cotton dust exposure; and

(*e*) The contents of this standard and its appendices.

(2) *Access to training materials.* (i) Each employer shall post a copy of this section with its Appendices in a public location at the workplace, and shall, upon request, make copies available to employees.

(ii) The employer shall provide all materials relating to the employee training and information program to the Assistant Secretary and the Director upon request.

(iii) An employer whose workforce consists of a significant percentage of Spanish speaking employees who cannot communicate effectively in English shall provide bi-lingual administration of the provisions of this section.

(iv) In addition to the information required by paragraph (f)(1), the employer shall include as part of his training program and distribute to employees any materials pertaining to the Occupational Safety and Health Act, the regulations issued pursuant to that Act, and to this cotton dust standard which are made available by the Assistant Secretary.

(g) *Signs.* (1) The employer shall post the following warning sign in each work area where there is potential exposure to cotton dust:

WARNING:

COTTON DUST WORK AREA MAY CAUSE ACUTE OR DELAYED LUNG INJURY (BYSSINOSIS).

(2) An employer whose workforce consists of a significant percentage of Spanish-speaking employees who cannot communicate effectively in English shall provide bilingual versions of the sign required by paragraph (g)(1) of this section.

(h) *Recordkeeping.*—(1) *Medical surveillance.* (i) The employer shall establish and maintain an accurate medical record for each employee subject to medical surveillance required by paragraph (e) of this section.

(ii) The record shall include:

(*a*) The name, social security number and description of the duties of the employee;

(*b*) A copy of the medical surveillance results including the medical history, questionnaire responses, results of all tests and the physician's recommendation;

(*c*) A copy of the physician's written opinion;

(*d*) Any employee medical complaints related to exposure to cotton dust;

(*e*) The type of protective devices worn, and length of time worn;

(*f*) A copy of this standard and its appendices, except that the employer may keep one copy of the standard and its appendices for all employees: *Provided,* That he references the standard in the medical surveillance records of each employee.

(ii) The employer shall maintain this record for at least 10 years.

(2) *Availability.* (i) The employer shall make available upon request all records required to be maintained by paragraph (h) of this section to the Assistant Secretary and the Director for examination and copying.

(ii) The employer shall make available an employee's medical records required by this section, for examination and copying, to the affected employee or former employee or to a physician or other individual designated by such affected employee or former employee.

(3) *Transfer of records.* (i) Whenever the employer ceases to do business, the successor employer shall receive and retain all records required to be maintained by paragraph (h) of this section.

(ii) Whenever the employer ceases to do business, and there is no successor employer to receive and retain the records for the prescribed period, these records shall be transmitted to the Director.

(iii) At the expiration of the retention period for the records required to be maintained by this section, the employer shall notify the Director at least 3 months prior to the disposal of such records and shall transmit those records to the Director if he requests them within that period.

(i) *Effective date.* This standard shall become effective on September 4, 1978 except for provisions requiring medical surveillance and respirators for employees who are at an increased exposure to cotton dust which shall become effective on September 4, 1979.

(j) *Appendices.* (1) Appendices to this section are incorporated as part of this section and the contents of these appendices are mandatory.

APPENDIX A.—*Recommendations for classification and respiratory use of workers exposed to cotton dust in gins*

Functional severity	FEV 1 (percent of predicted)	FEV 1 (percent)
P0	Greater than 80 (no evidence of chronic ventilatory impairment).	(a) −4 to 0; or more. (b) −9 to −5 or more. (c) −10 or more.
F1	60-79 (evidence of slight to moderate irreversible impairment of ventilatory capacity).	(a) −4 to 0; or more. (b) −5 or more.
P2	Less than 60 (evidence of moderate to severe irreversible impairment of ventilatory capacity).	....

NOTE.—These recommendations are generally accepted criteria for classification and management of workers exposed to cotton dust. Since medical removal provisions are not included in the standard, OSHA believes them to constitute equally useful criteria for the physician to use in determining whether a gin worker is suffering any degree of functional severity which calls for respiratory protection.

Although these criteria are advisory, a worker who falls in the F2 category of functional severity shall be sent to a pulmonary physician according to § 1910.1046a(e)(4)(iii).

APPENDIX B-I
RESPIRATORY QUESTIONNAIRE

A. IDENTIFICATION DATA

PLANT_____ SOCIAL SECURITY NO. _____
DAY MONTH (figures) YEAR (last 2 digits)

NAME_____ DATE OF INTERVIEW_____
(Surname)

_____ _____ DATE OF BIRTH_____
(First Names) M F

ADDRESS_____ AGE_____(8,9) SEX_____(10)

_____ RACE W N IND. OTHER (11)

INTERVIEWER: 1 2 3 4 5 6 7 8 (12)

WORK SHIFT: 1st_____ 2nd_____ 3rd_____(13) STANDING HEIGHT_____(14,15)

PRESENT WORK AREA WEIGHT_____(16,18)

If working in more than one specified work area, X area where most of the work shift is spent. If "other," but spending 25% of the work shift in one of the specified work areas, classify in that work area. If carding department employee, check area within that department where most of the work shift is spent (if in doubt, check "throughout"). For work areas such as spinning and weaving where many work rooms may be involved, be sure to check the specific work room to which employee is assigned — if he works in more than one work room within a department classify as 7 (all) for that department.

	Workroom Number	(19) Open	(20) Pick	Area	(21) Card #1	(22) #2	(23) Spin	(24) Wind	(25) Twist	(26) Spool	(27) Warp	(28) Slash	(29) Weave	(30) Other
AT RISK (cotton & cotton blend)	1			Cards										
	2			Draw										
	3			Comb										
	4			Rove										
	5 —			Thru Out										
	6													
	7 - (all)													
Control (synthetic & wool)	8													
Ex-Worker (cotton)	9													

Use actual wording of each question. Put X in appropriate square after each question. When in doubt record 'No'. When no square, circle appropriate answer.

B. COUGH

Do you usually cough (on getting up)† first thing in the morning? (Count a cough with first smoke or on "first going out of doors." Exclude clearing throat or a single cough.) Yes___ No___ (31)

Do you usually cough during the day or at night? (Ignore an occasional cough.) Yes___ No___ (32)

If 'Yes' to either question (31-32):

Do you cough like this on most days for as much as three months a year? Yes___ No___ (33)

Do you cough on any particular day of the week? Yes___ No___ (34)

(1) (2) (3) (4) (5) (6) (7)

If 'Yes': Which day? Mon. Tues. Wed. Thur. Fri. Sat Sun. (35)

C. PHLEGM or alternative word to suit local custom.

Do you usually bring up any phlegm from your chest (on getting up)† first thing in the morning? (Count phlegm with the first smoke or on "first going out of doors." Exclude phlegm from the nose. Count swallowed phlegm.) Yes___ No___ (36)

Do you usually bring up any phlegm from your chest during the day or at night? (Accept twice or more.) Yes___ No___ (37)

If 'Yes' to either question (36) or (37):

Do you bring up phlegm like this on most days for as much as three months each year? Yes___ No___ (38)

If 'Yes' to question (33) or (38):

How long have you had this (cough) phlegm? (Write in number of years

(1) ☐ 2 years or less
(2) ☐ More than 2 years-9 years
(3) ☐ 10-19 years
(4) ☐ 20+ years

†These words are for subjects who work at night

D. CHEST ILLNESSES

In the past three years, have you had a period of (increased) †cough and phlegm lasting for 3 weeks or more? (1) ☐ No (40)
(2) ☐ Yes, only one period
(3) ☐ Yes, two or more periods

†For subjects who usually have phlegm

During the past 3 years have you had any chest illness which has kept you off work, indoors at home or in bed? (For as long as one week, flu?) Yes___ No___ (41)

If 'Yes' to (41): Did you bring up (more) phlegm than usual in any of these illnesses? Yes___ No___ (42)

If 'Yes' to (42): During the past three years have you had:
Only one such illness with increased phlegm? (1) ☐ (43)
More than one such illness: (2) ☐ (44)

Br. Grade___

E. TIGHTNESS

Does your chest ever feel tight or your breathing become difficult?_____Yes_____No____(45)

Is your chest tight or your breathing difficult on any particular day of the week? (after a week or 10 days away from the mill)_____Yes_____No____(46)

If 'Yes': Which day? Mon. (3) Tues. (4) Wed. (5) Thur. (6) Fri. (7) Sat. (8) Sun. (47)

(1) Sometimes (2) Always

If 'Yes' Monday: At what time on Monday does your chest feel tight or your breathing difficult? 1 ☐ Before entering the mill (48)

2 ☐ After entering the mill

(Ask only if NO to Question (45))

In the past, has your chest ever felt tight or your breathing difficult on any particular day of the week?_____Yes_____No____(49)

If 'Yes': Which day? Mon. (3) Tues. (4) Wed. (5) Thur. (6) Fri. (7) Sat. (8) Sun. (50)

(1) Sometimes (2) Always

F. BREATHLESSNESS

If disabled from walking by any condition other than heart or lung disease put "X" here and leave questions (52-60) unasked. ☐ (51)

Are you ever troubled by shortness of breath, when hurrying on the level or walking up a slight hill?_____Yes_____No____(52)

If 'No', grade is 1. If 'Yes' proceed to next question

Do you get short of breath walking with other people at an ordinary pace on the level?_____Yes_____No____(53)

If 'No', grade is 2. If 'Yes', proceed to next question

Do you have to stop for breath when walking at your own pace on the level?_____Yes_____No____(54)

If 'No', grade is 3. If 'Yes', proceed to next question

Are you short of breath on washing or dressing?_____Yes_____No____(55)

If 'No', grade is 4. If 'Yes', grade is 5.

Dyspnea Grd._____(56)

ON MONDAYS:

Are you ever troubled by shortness of breath, when hurrying on the level or walking up a slight hill?_____Yes_____No____(57)

If 'No', grade is 1. If 'Yes', proceed to next question

Do you get short of breath walking with other people at an ordinary pace on the level?_____Yes_____No____(58)

If 'No', grade is 2. If 'Yes', proceed to next question

Do you have to stop for breath when walking at your own pace on the level?_____Yes_____No____(59)

If 'No', grade is 3. If 'Yes', proceed to next question

Are you short of breath on washing or dressing?_____Yes_____No____(60)

If 'No', grade is 4. If 'Yes', grade is 5

B. Grd._____(61)

G. OTHER ILLNESSES AND ALLERGY HISTORY

Do you have a heart condition for which you are under a doctor's care? ____ Yes ____ No ____ (62)

Have you ever had asthma? Yes No (63)

If 'Yes', did it begin: (1) ☐ Before age 30
(2) ☐ After age 30

If 'Yes' before 30: did you have asthma before ever going to work in a textile mill? ____ Yes ____ No ____ (64)

Have you ever had hay fever or other allergies (other than above)? ____ Yes ____ No ____ (65)

H. TOBACCO SMOKING*

Do you smoke?

Record 'Yes' if regular smoker up to one month ago. (Cigarettes, cigar or pipe) ____ Yes ____ No ____ (66)

If 'No' to (63).

Have you ever smoked? (Cigarettes, cigars, pipe. Record 'No' if subject has never smoked as much as one cigarette a day, or 1 oz. of tobacco a month, for as long as one year.) ____ Yes ____ No ____ (67)

If 'Yes' to (63) or (64); what have you smoked and for how many years? (Write in specific number of years in the appropriate square)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
Years	(<5)	(5-9)	(10-14)	(15-19)	(20-24)	(25-29)	(30-34)	(35-39)	(>40)	
Cigarettes										(68)
Pipe										(69)
Cigars										(70)

If cigarettes, how many packs per day? (Write in number of cigarettes)

(1) ☐ less than 1/2 pack (71)
(2) ☐ 1/2 pack, but less than 1 pack
(3) ☐ 1 pack, but less than 1-1/2 packs
(4) ☐ 1-1/2 packs or more

Number of pack years: ____ (72,73)

If an ex-smoker (cigarettes, cigar or pipe), how long since you stopped? (Write in number of years) ____ (74)

(1) ☐ 0-1 year
(2) ☐ 1-4 years
(3) ☐ 5-9 years
(4) ☐ 10+ years

*Have you changed your smoking habits since last interview? If yes, specify what changes.

I. OCCUPATIONAL HISTORY**

Have you ever worked in: A foundry? (As long as one year) ____ Yes ____ No ____ (75)

Stone or mineral mining, quarrying or processing? (As long as one year) ____ Yes ____ No ____ (76)

Asbestos milling or processing? (Ever) ____ Yes ____ No ____ (77)

Other dusts, fumes or smoke? If yes, specify: ____ Yes ____ No ____ (78)

Type of exposure ____

Length of exposure ____

**Ask only on first interview.

At what age did you first go to work in a textile mill? (Write in specific age in appropriate square).

(1)	(2)	(3)	(4)	(5)	(6)	
<20	20-24	25-29	30-34	35-39	40+	(79)

When you first worked in a textile mill, did you work with (1) ☐ Cotton or cotton blend (80)
(2) ☐ Synthetic or wool

APPENDIX B-II

Respiratory Questionnaire
for
Non-Textile Workers for the
Cotton Industry

Identification No. Interviewer Code

Location Date of Interview

A. IDENTIFICATION

1. NAME (Last) (First) (Middle Initial)

3. PHONE NUMBER AREA CODE ( ) NO.

4. SOCIAL SECURITY # (optional see below)

2. CURRENT ADDRESS (Number, Street, or Rural Route, City or Town, County, State, Zip Code)

5. BIRTHDATE (Mo., Day, Yr.)

6. AGE LAST BIRTHDAY

7. SEX

1 ☐ Male 2 ☐ Female

8. ETHNIC GROUP OR ANCESTRY

1. ☐ White, not of Hispanic Origin
2. ☐ Black, not of Hispanic Origin
3. ☐ Hispanic
4. ☐ American Indian or Alaskan Native
5. ☐ Asian or Pacific Islander
6. ☐ Other: _____

9. STANDING HEIGHT _____ (cm)

10. WEIGHT _____

11. WORK SHIFT

1st ☐ 2nd ☐ 3rd ☐

12. PRESENT WORK AREA

Please indicate primary assigned work area and percent of time spent at that site. If at other locations, please indicate and note percent of time for each.

PRIMARY WORK AREA	
SPECIFIC JOB	

13. APPROPRIATE INDUSTRY

1 ☐ Garnetting
2 ☐ Cottonseed Oil Mill
3 ☐ Cotton Warehouse
4 ☐ Utilization
5 ☐ Cotton Classification
6 ☐ Cotton Ginning

(Furnishing your Social Security number is voluntary. Your refusal to provide this number will not affect any right, benefit, or privilege to which you would be entitled if you did provide your Social Security number. Your Social Security number is being requested since it will permit use in future determinations in statistical research studies.)

B. OCCUPATIONAL HISTORY TABLE

Complete the following table showing the entire work history of the individual from present to initial employment. Sporadic, part-time periods of employment, each of no significant duration, should be grouped if possible.

INDUSTRY AND LOCATION	TENURE OF EMPLOYMENT		SPECIFIC OCCUPATION	AVERAGE NO. DAYS WORKED PER WEEK	HAZARDOUS HEALTH EXPOSURE ASSOCIATED WITH WORK		
	FROM 19__	TO 19__			YES	NO	IF YES, DESCRIBE

C. SYMPTOMS

Use actual wording of each question. Put X in appropriate square after each question. When in doubt record "No".

COUGH

1. Do you usually cough first thing in the morning? (on getting up)* (Count a cough with first smoke or on "first going out of doors". Exclude clearing throat or a single cough.) 1 ☐ Yes 2 ☐ No

2. Do you usually cough during the day or at night? (Ignore an occasional cough.) 1 ☐ Yes 2 ☐ No

If YES to either question 1 or 2:

3. Do you cough like this on most days for as much as three months a year? 1 ☐ Yes 2 ☐ No 9 ☐ NA

4. Do you cough on any particular day of the week? 1 ☐ Yes 2 ☐ No

If YES:

5. Which day? Mon. Tue. Wed. Thur. Fri. Sat. Sun. _____

PHLEGM

6. Do you usually bring up any phlegm from your chest first thing in the morning? (on getting up)* (Count phlegm with the first smoke or on "first going out of doors." Exclude phlegm from the nose. Count swallowed phlegm.) 1 ☐ Yes 2 ☐ No

7. Do you usually bring up any phlegm from your chest during the day or at night? (Accept twice or more.) 1 ☐ Yes 2 ☐ No

If YES to either question 6 or 7:

8. Do you bring up phlegm like this on most days for as much as three months each year? 1 ☐ Yes 2 ☐ No

If YES to question 3 or 8:

9. How long have you had this phlegm? (cough) (Write in number of years)

(1) ☐ 2 years or less
(2) ☐ More than 2 years - 9 years
(3) ☐ 10-19 years
(4) ☐ 20+ years

*These words are for subjects who work at night

CHEST ILLNESS

10. In the past three years, have you had a period of (increased) cough and phlegm lasting for 3 weeks or more?
(1) ☐ No
(2) ☐ Yes, only one period
(3) ☐ Yes, two or more periods

For subjects who usually have phlegm:

11. During the past 3 years have you had any chest illness which has kept you off work, indoors at home or in bed? (For as long as one week, flu?) 1 ☐ Yes 2 ☐ No

If YES to 11:

12. Did you bring up (more) phelgm than usual in any of these illnesses? 1 ☐ Yes 2 ☐ No

If YES to 12: During the past three years have you had:

13. Only one such illness with increased phelgm? 1 ☐ Yes 2 ☐ No

14. More than one such illness: 1 ☐ Yes 2 ☐ No

Br. Brade _____

TIGHTNESS

15. Does your chest ever feel tight or your breathing become difficult? 1 ☐ Yes 2 ☐ No

16. Is your chest tight or your breathing difficult on any particular day of the week? (after a week or 10 days away from the mill) 1 ☐ Yes 2 ☐ No

17. If YES, Which day? Mon. (3) Tues. (4) Wed. (5) Thur. (6) Fri. (7) Sat. (8) Sun.
(1) Sometimes (2) Always

18. If YES Monday: At what time on Monday does your chest feel tight or your breathing difficult?
☐ Before entering mill
☐ After entering mill

(ASK ONLY IF NO TO QUESTION 15)

19. In the past, has your chest ever been tight or your breathing difficult on any particular day of the week? 1 ☐ Yes 2 ☐ No

20. If YES, Which day? Mon. (3) Tues. (4) Wed. (5) Thur. (6) Fri. (7) Sat. (8) Sun.
(1) Sometimes (2) Always

BREATHLESSNESS

21. If disabled from walking by any condition other than heart or lung disease put "X" in the space and leave questions (22-30) unasked. ☐

22. Are you ever troubled by shortness of breath, when hurrying on the level or walking up a slight hill? 1 ☐ Yes 2 ☐ No

If NO, grade is 1. If YES, proceed to next question

23. Do you get short of breath walking with other people at an ordinary pace on the level? 1 ☐ Yes 2 ☐ No

If NO, grade is 2. If YES, proceed to next question

24. Do you have to stop for breath when walking at your own pace on the level? 1 ☐ Yes 2 ☐ No

If NO, grade is 3. If YES, proceed to next question

25. Are you short of breath on washing or dressing? 1 ☐ Yes 2 ☐ No

If NO, grade is 4. If YES, grade is 5.

26. Dyspnea Grd. _____

ON MONDAYS:

27. Are you ever troubled by shortness of breath, when hurrying on the level or walking up a slight hill? 1 ☐ Yes 2 ☐ No

If NO, grade is 1. If YES, proceed to next question

28. Do you get short of breath walking with other people at an ordinary pace on the level? 1 ☐ Yes 2 ☐ No

If NO, grade is 2, If YES, proceed to next question

29. Do you have to stop for breath when walking at your own pace on the level? 1 ☐ Yes 2 ☐ No

If NO, grade is 3. If YES, proceed to next question

30. Are you short of breath on washing or dressing? 1 ☐ Yes 2 ☐ No

If NO, grade is 4. If YES, grade is 5

31. B. Grd. _____

OTHER ILLNESSES AND ALLERGY HISTORY

32. Do you have a heart condition for which you are under a doctor's care? 1 ☐ Yes 2 ☐ No

OTHER ILLNESSES AND ALLERGY HISTORY CONTINUED:

33. Have you ever had asthma? 1 ☐ Yes 2 ☐ No

If yes, did it begin: (1) Before age 30 ☐

(2) After age 30 ☐

34. If yes before 30: did you have asthma before ever going to work in a textile mill? 1 ☐ Yes 2 ☐ No

35. Have you ever had hay fever or other allergies (other than above)? 1 ☐ Yes 2 ☐ No

TOBACCO SMOKING

36. Do you smoke? 1 ☐ Yes 2 ☐ No
Record Yes if regular smoker up to one month ago. (Cigarettes, cigar or pipe)

If NO to (33).

37. Have you ever smoked? (Cigarettes, cigars, pipe. Record NO if subject has never smoked as much as one cigarette a day, or 1 oz. of tobacco a month, for as long as one year.) 1 ☐ Yes 2 ☐ No

If Yes to (33) or (34); what have you smoked for how many years? (Write in specific number of years in the appropriate square)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Years	(<5)	(5-9)	(10-14)	(15-19)	(20-24)	(25-29)	(30-34)	(35-39)	(>40)
38. Cigarettes									
39. Pipe									
40. Cigars									

41. If cigarettes, how many packs per day? Write in number of cigarettes _____

☐ Less than 1/2 pack
☐ 1/2 pack, but less than 1 pack
☐ 1 pack, but less than 1 1/2 packs
☐ 1-1/2 packs or more

42. Number of pack years: _____

43. If an ex-smoker (cigarettes, cigar or pipe), how long since you stopped? (Write in number of years.) _____

☐ 0-1 year
☐ 1-4 years
☐ 5-9 years
☐ 10+ years

OCCUPATIONAL HISTORY

Have you ever worked in:

44. A foundry? (As long as one year) 1 ☐ Yes 2 ☐ No

45. Stone or mineral mining, quarrying or processing? (As long as one year) 1 ☐ Yes 2 ☐ No

46. Asbestos milling or processing? (Ever) 1 ☐ Yes 2 ☐ No

47. Cotton or cotton blend mill? (For controls only) 1 ☐ Yes 2 ☐ No

48. Other dusts, fumes or smoke? If yes, specify. 1 ☐ Yes 2 ☐ No

Type of exposure _____

Length of exposure _____

APPENDIX B-III

ABBREVIATED RESPIRATORY QUESTIONNAIRE

A. IDENTIFICATION DATA

PLANT _____ SOCIAL SECURITY NO. _____
DAY MONTH (figures) YEAR (last 2 digits)

NAME _____ DATE OF INTERVIEW _____
(Surname)

_____ _____ DATE OF BIRTH _____
(First Names) M F

ADDRESS _____ AGE _____ (8,9) SEX _____ (10)

_____ RACE | W | N | IND. | OTHER | (11)

INTERVIEWER: 1 2 3 4 5 6 7 8 (12)

WORK SHIFT: 1st _____ 2nd _____ 3rd _____ (13) STANDING HEIGHT _____ (14,15)

PRESENT WORK AREA WEIGHT _____ (16,18)

If working in more than one specified work area, X area where most of the work shift is spent. If "other," but spending 25% of the work shift in one of the specified work areas, classify in that work area. If carding department employee, check area within that department where most of the work shift is spent (if in doubt, check "throughout"). For work areas such as spinning and weaving where many work rooms may be involved, be sure to check the specific work room to which employee is assigned — if he works in more than one work room within a department classify as 7 (all) for that department.

	Workroom Number	(19) Open	(20) Pick	Area	(21) Card #1	(22) #2	(23) Spin	(24) Wind	(25) Twist	(26) Spool	(27) Warp	(28) Slash	(29) Weave	(30) Other
AT RISK (cotton & cotton blend)	1			Cards										
	2			Draw										
	3			Comb										
	4			Rove										
	5 —			Thru Out										
	6													
	7 (all)													
Control (synthetic & wool)	8													
Ex-Worker (cotton)	9													

Use actual wording of each question. Put X in appropriate square after each question. When in doubt record 'No'. When no square, circle appropriate answer.

B. COUGH

Do you usually cough first thing in the morning? (on getting up)† _____ Yes ___ No ___ (31)
(Count a cough with first smoke or on "first going out of doors." Exclude clearing throat or a single cough.)

Do you usually cough during the day or at night? _____ Yes ___ No ___ (32)
(Ignore an occasional cough.)

If 'Yes' to either question (31-32):

Do you cough like this on most days for as much as three months a year? _____ Yes ___ No ___ (33)

Do you cough on any particular day of the week? _____ Yes ___ No ___ (34)

(1) (2) (3) (4) (5) (6) (7)

If 'Yes': Which day? Mon. Tues. Wed. Thur. Fri. Sat Sun. (35)

C. PHLEGM or alternative word to suit local custom.

Do you usually bring up any phlegm from your chest first thing in the morning? (Count phlegm with the first smoke or on "first going out of doors." Exclude phlegm from the nose. Count swallowed phlegm.) (on getting up)† _____ Yes ___ No ___ (36)

Do you usually bring up any phlegm from your chest during the day or at night? (Accept twice or more.) _____ Yes ___ No ___ (37)

If 'Yes' to either question (36) or (37):

Do you bring up phlegm like this on most days for as much as three months each year? _____ Yes ___ No ___ (38)

If 'Yes' to question (33) or (38):

How long have you had this phlegm? (cough)
(Write in number of years

(1) ☐ 2 years or less
(2) ☐ More than 2 years-9 years
(3) ☐ 10-19 years
(4) ☐ 20+ years

†These words are for subjects who work at night

D. TIGHTNESS

Does your chest ever feel tight or your breathing become difficult? _____ Yes ___ No ___ (39)

Is your chest tight or your breathing difficult on any particular day of the week? (after a week or 10 days away from the mill) _____ Yes ___ No ___ (40)

If 'Yes': Which day? Mon. (1) Tues. (2) Wed. (3) Thur. (4) Fri. (5) Sat. (6) Sun. (7) (8) (41)
(1) Sometimes (2) Always

If 'Yes' Monday: At what time on Monday does your chest feel tight or your breathing difficult? 1 ☐ Before entering the mill 2 ☐ After entering the mill (42)

(Ask only if NO to Question (45)*

In the past, has your chest ever been tight or your breathing difficult on any particular day of the week? _____ Yes ___ No ___ (43)

If 'Yes': Which day? Mon. (1) Tues. (2) Wed. (3) Thur. (4) Fri. (5) Sat. (6) Sun. (7) (8) (44)
(1) Sometimes (2) Always

E. TOBACCO SMOKING*

*Have you changed your smoking habits since last interview? If yes, specify what changes.

APPENDIX B-IV
Cuestionario Medico

1. Nótese: ¿Muestra el sujeto señales de resfraido o síntomas de grave infección respiratoria? ☐ Sí ☐ No (1)

2. Caso núm. _____ (2-6)

A. DATOS DE IDENTIFICACION

3. Desmotadora: _____ (7-11)

4. Nombre: _____ (Apellido)
_____ (Nombre de pila)

5. Dirección: _____
_____ (Ciudad)

6. Entrevistador: 1 2 3 4 5 6 7 8 (12-13)

7. Turno de Trabajo: 1 ____ 2 ____ (14)

8. Sitio de Trabajo Actual: (15)
   a. Balancero
   b. Corralero
   c. Succionero
   d. Desmotador
   e. Ayudante de desmotador
   f. Comprimidor
   g. Desemillador
   h. Basurero
   i. Quitahilachas
   j. Embalador

9. Número de Seguro Social
___-___-___ (16-24)

10. Fecha de Entrevista:
Mes Día Año
___/ ___/ ___/ (25-30)

11. Hora: _____ de la mañana / de la tarde

12. Fecha de Nacimiento:
Mes Día Año
___/ ___/ ___/

13. Edad: _____ (31-32)

14. Sexo: Varón___ Hembra ___ (33)

15. Raza: B___N___M___O___ (34)

16. Altura Medida:____(Pulgadas) (35-37)

17. Peso Medido:_____(Libras) (38-40)

SINTOMAS RESPIRATORIAS

EMPLÉENSE LAS PALABRAS EXACTAS DE CADA PREGUNTA. PÓNGASE UNA "X" EN LA CASILLA QUE SIGUE CADA PREGUNTA. EN CASO DE DUDA, PÓNGASE "NO". DONDE NO HAY CASILLA, PÓNGASE UN CÍRCULO ALREDEDOR DE LA RESPUESTA APROPIADA.

INTRODUCCIÓN: LE VOY A HACER UNAS PREGUNTAS, POR LA MAYOR PARTE ACERCA DE LOS PULMONES. QUIERO QUE CONTESTE CON "SÍ" O "NO" CUANDO SEA POSIBLE.

B. LA TOS

18. ¿Tose Ud. ordinariamente al levantarse por la mañana? ☐ Sí ☐ No (41)

19. ¿Tose Ud. ordinariamente de día o de noche? ☐ Sí ☐ No (42)

20. Si se contesta "Sí" a la pregunta 18 o 19, pregúntese: ¿Ha tosido así la mayoría de los días por un periodo de 3 meses durante el año pasado? ☐ Sí ☐ No ☐ NR (43)

21. Si se contesta "Sí" a 20, pregúntese: ¿Cuántos años hace que tose de esta manera?
Menos de 2 años _____ Más de 2 años _____ NR __ (44-45)

C. LA FLEMA (u otra palabra de uso local):

22. ¿Se arranca Ud. flema del pecho ordinariamente al levantarse? (Tenga en cuenta la flema arrancada al fumar o al salir de la casa por primera vez. No tenga en cuenta los mucos nasales. Tenga en cuenta la flema que se traga.)

☐ Sí ☐ No (46)

23. ¿Se arranca Ud. alguna flema del pecho ordinariamente de día o de noche? (Nótense sólo 2 veces o más)

☐ Sí ☐ No (47)

24. Si se contesta "Sí" a la pregunta 22 o 23, pregúntese: ¿Se ha arrancado flemas la mayoría de los días por un periodo de 3 meses durante el año pasado?

☐ Sí ☐ No ☐ NR (48)

25. Si se contesta "Sí" a 24, pregúntese: ¿Cuántos años hace que se arranca flemas así? _____Años

Menos de 2 años | Mas de 2 años | NR
_____ | _____ | ____ (49-50)

D. ENFERMEDADES PULMONARIAS

26. ¿Durante los tres años pasados, ha pasado algún periodo de tos* (aumentada) y flemas que duró 3 semanas o más?

* Sujetos que ordinariamente se arrancan flemas

☐ No
☐ Sí, uno solo
☐ Sí, dos o más (51)

27. ¿Ha tenido Ud. durante los 3 años pasados alguna enfermedad del pecho que le haya impedido a trabajar o le haya obligado a permanecer en casa, en cama por tanto como una semana? (Por ejemplo: ¿la gripe?)

☐ Sí ☐ No (52)

28. Si se contesta "Sí" a 27, pregúntese: ¿se arrancó Ud. más flemas que lo general durante alguno de estos ataques?

☐ Sí ☐ No ☐ NR (53)

29. Si se contesta "Sí" a 28, pregúntese: ¿Ha tenido durante los tres anos pasados:

Sólo un tal ataque con aumento de flemas? ____
Más de uno? ____
No cabe ____ (54)

30. Br. Grade
0_____(0)
1_____(1)
2_____(2)
3_____(3) (55)

31. ¿Resuella ruidosamente o tiene silbidos alguna vez en el pecho?

☐ Sí ☐ No (56)

32. Si se contesta "Sí" a 31, pregúntese: ¿Cuántas veces por año pasa eso? _____Veces

Menos de 50 | Más de 50 | NR
_____ | _____ | ____ (57-58)

E. LA DISPNEA (desaliento)

33. Sufre Ud. ataques de desaliento que no se relacionan con ningún esfuerzo físico? ☐ Sí ☐ No (59)

34. Si se contesta "Sí" a 33, pregúntese: Cuántos de tales ataques ha sufrido durante el año pasado? _____Ataques — Menos de 50 _____ Mas de 50 _____ NR _ (60-61)

35. Si se inhabilita de caminar a causa de cualquier condicion que no sea enfermedad del corazón o del pecho, ponga una "X" y especifique: _ _____ (62)

36. ¿Lo aflige un desaliento al caminar aprisa en terreno llano o al subir una pequeña cuesta? ☐ Sí ☐ No (63)

(Si "No," el grado es 1. Si es "Sí," siga a la pregunta siguiente.)

37. ¿Lo aflige un desaliento al caminar con otros de su propia edad a su paso ordinario en terreno llano? ☐ Sí ☐ No ☐ NR (64)

(Si "No," el grado es 2. Si es "Sí," prosiga)

38. ¿Tiene que detenerse porque se ahoga al caminar a paso ordinario en terreno llano? ☐ Sí ☐ No ☐ NR (65)

(Si "No," el grado es 3. Si es "Sí," prosiga)

39. ¿Se desalienta al lavarse o vestirse? ☐ Sí ☐ No ☐ NR (66)

(Si "No," el grado es 4. Si es "Sí," el grado es 5)

40. Dyspnea Grd._____ (67)

Introducción para las preguntas 40-43:

EL PRIMER DIA DE VUELTA AL TRABAJO DESPUES DE SUS DIAS LIBRES:

41. ¿Lo aflige un desaliento al caminar aprisa en terreno llano o al subir una pequeña cuesta? ☐ Sí ☐ No (68)

(Si "No," el grado es 1. Si es "Sí," siga a la pregunta siguiente.)

42. ¿Lo aflige un desaliento al caminar con otros de su propia edad a su paso ordinario en terreno llano? ☐ Sí ☐ No ☐ NR (69)

(Si "No," el grado es 2. Si es "Sí," prosiga)

43. ¿Tiene que detenerse porque se ahoga al caminar a paso ordinario en terreno llano? ☐ Sí ☐ No ☐ NR (70)

(Si "No," el grado es 3. Si es "Sí," prosiga)

44. ¿Se desalienta al lavarse o vestirse? ☐ Sí ☐ No ☐ NR (71)

(Si "No," el grado es 4. Si es "Sí," el grado es 5)

45. B. Grd. 0 _____ (0)
1/2 _____ (1)
1 _____ (2)
— 2 _____ (3)
— 3 _____ (4) (72)

46. ¿Ha tosido más que lo usual durante la semana pasada?

Fecha		(73)
Sí		
No		

47. ¿Se ha arrancado flemas del pecho o de día o de noche durante la semana pasada?

Sí		(74)
No		

48. ¿Ha tenido un "resfriado del pecho" durante la semana pasada?

Fecha		(75)
Sí		
No		

F. LA OPRESION EN EL PECHO

49. ¿Tiene Ud. alguna vez opresión en el pecho o dificultad de respirar?

Sí		(76)
No		

50. ¿Se le oprime el pecho o se le hace difícil respirar algún día de la semana en particular?

Sí		(77)
No		

51. Si se contesta "Sí" a 50, pregúntese: ¿Cuál día?

D		(78-85)
L		
Mar.		
Mier.		
J		
V		
S		
Siempre		
A veces		
NR		

52. ¿Se le oprime el pecho o se le hace difícil respirar:

Fecha		(86-89)
a. ¿El primer día de vuelta al trabajo después de un día libre o más?		
b. ¿El segundo día de vuelta al trabajo después de un día libre o más?		
c. ¿El último día de trabajo antes de un día libre?		
d. No cabe ninguna de las preguntas de arriba.		

53. Si se contesta "Sí" a 52, pregúntese: ¿ Siente opresión en el pecho o se le hace difícil respirar:

a. En todas tales ocasiones?
b. Sólo a veces.
c. No cabe.

Fecha | | | | | | | | | | | | (90-92)

54. Si se contesta "Sí" a la pregunta 50 o 52, pregúntese: ¿ A qué hora del día indicado siente opresión en el pecho o dificultad de respirar?

a. Antes de entrar en la desmotadora.
b. Después de entrar en la desmotadora.
c. Después de salir de la desmotadora.
d. No cabe.

Fecha | | | | | | | | | | | | (93-96)

55. Si la respuesta a 54 "b" o "c" es afirmativa, prequntese: ¿ Cuántas horas después de empezar un turno comienza esto?

Horas_____
No cabe_____ (97-98)

56. Si la respuesta a 54 "b" o "c" es afirmativa, pregúntese: ¿ Cuánto tiempo dura esta opresión o dificultad de respirar?

Horas_____
No cabe_____ (99-100)

57. (Pregúntese sólo si se contesta "No" a 50) En el pasado, ha sentido alguna vez opresión en el pecho o dificultad de respirar algún día de la semana en particular?

☐ Sí ☐ No ☐ NR (101)

58. Si se contesta "Sí" a 57, pregúntese: Cuál día?

D_____
L_____
Mar._____
Mier._____
J_____ Siempre___
V_____ A veces___
S_____ NR_____ (102)

59. (Pregúntese sólo si se contesta "No" a 52) ¿ En el pasado, ha sentido alguna vez opresión en el pecho o dificultad de respirar?

a. El primer día de vuelta al trabajo después de un día libre o más. a._____

b. El segundo día de vuelta al trabajo después de un día libre o más. b._____

c. El último día de trabajo antes de un día libre. c._____ (103)

d. No cabe nada de lo de arriba. d._____

e. NR. e._____

60. Si se contesta "Sí" a 59, pregúntese:
¿ Sentía Ud. opresión en el pecho o dificultad de respirar?

a. En toda (o casi toda) ocasion a____
b. Sólo a veces b____ (104)
c. No cabe c____

61. Si se contesta "Sí" a 50, 52, 57, O 59, pregúntese:
¿ Cuantos años hace que siente opresión en el pecho o dificultad de respirar? ____ Años ☐ NR (105-106)

C. HISTORIA LABORAL

62. ¿ Qué clase de trabajo hace Ud. cuando no desmote el algodón (Especifique)? _____ (107)

Introducción para las preguntas 63 a 69: ¿ Ha trabajado Ud. alguna vez en:

63. Una fundición (por tanto como un año)? ☐ Sí ☐ No (108)

64. La minería o elaboración de piedra o metales (por tanto como un año)? ☐ Sí ☐ No (109)

65. En una planta de asbesto (alguna vez)? ☐ Sí ☐ No (110)

66. En una fábrica de textil de algodón, de mezclado de algondon o de aceite de semilla de algodón? ☐ Sí ☐ No (111)

67. En el cosecho de algodón o cereales? ☐ Sí ☐ No (112)

68. En una desmotadora de algodón (sólo para el grupo de control)? ☐ Sí ☐ No (113)

69. En proximidad de otros polvos, emanaciones o humos? Si se contesta "Sí," especifíquese: ☐ Sí ☐ No (114)
Clase de contacto_____
Duración de contacto_____

70. ¿ Cuántos años tenía cuando empezó a trabajar por primera vez en una desmotadora de algodón? (Escríbase su edad exacta)_____ (115-116)

71. ¿ Cuántos años hace que trabaja en una desmotadora de algodón? (Número total de años)_____ (117-118)

72. ¿ Cuántos meses por año trabaja ordinariamente en una desmotadora de algodón?_____ (Núm. de meses) (119-120)

73. ¿ En qué otras regiones del estado o del país ha trabajado (desmotando el algodón)?_____ (121-122)

H. OTRAS ENFERMEDADES

74. ¿Tiene Ud. una condición del corazón que requiere los servicios de un médico? ☐ Sí ☐ No (123)

75. Si se contesta "Sí" a 74, especifíquense la condición_____

la medicacion:_____

No cabe:_____

76. ¿Ha tenido alguna vez asma? ☐ Sí ☐ No (124)

77. Si se contesta "Si" a 76, pregúntese si empezó: ___Antes de los 30 anos
___Despues de los 30 anos
___NR

78. Si se contesta "Sí" a 76, pregúntese: Tenía asma antes de trabajar en una desmotadora de algodón? ☐ Sí ☐ No ☐ NR (125)

79. ¿Le ha dicho alguna vez un medico que Ud. Tenía alguna de lás condiciones que siguen?

a. Bronquitis crónica ☐ Sí ☐ No (126)

b. Enfisema ☐ Sí ☐ No (127)

c. Infección fungoso de los pulmones ☐ Sí ☐ No (128)

d. Tisis (tuberculosis) ☐ Sí ☐ No (129)

e. Cualquier condición crónica de los pulmones ☐ Sí ☐ No (130)

Si se contesta "Sí," especifíquese:_____

_____

_____

I. CONSUMO DE TABACO

80. ¿Ha fumado Ud. alguna vez cigarrillos? ☐ Sí ☐ No (131)

(Si se contesta "Sí" a 80, pregúntese 81. Si "No," omítase lo que no quepa.)

81. ¿Fuma cigarrillos actualmente? ☐ Sí ☐ No ☐ NR (132)

(Si se contesta "Sí" a 81, pregúntese 82 a 84. Si "No," pregúntese 85 a 87.)

82. ¿Aproximadamente cuántos cigarrillos fuma ordinariamente por día? ____ Número ☐ NR (133-134)

83. ¿Inhala (aspira), digo, traga el humo? ☐ Sí ☐ No ☐ NR (135)

84. ¿Cuántos años hace que fuma cigarrillos? ____ Años ☐ NR (136-137)

(Omítase hasta 88)

85. ¿Cuando fumaba, cuántos cigarrillos consumía por dia? ____ Número ☐ NR (138-139)

86. ¿Inhalaba (aspiraba), digo, tragaba el humo? ☐ Si ☐ No ☐ NR (140)

87. ¿Aproximadamente cuántos años hacía que fumaba cigarrillos? ___ Años ☐ NR (141-142)

88. ¿Ha fumado alguna vez puros? ☐ Si ☐ No (143)

(Si se contesta "Si" a 88, pregúntese 89 a 91. Si "No," omítase hasta 92.)

89. ¿Fuma puros actualmente? ☐ Si ☐ No ☐ NR (144)

(Si se contesta "Si" a 89, pregúntese 90 a 91. Si "No," omítase hasta 92.)

90. ¿Aprximadamente cuántos puros fuma ordinariamente por día? ___ Número ☐ NR (145-146)

91. ¿Aproximadamente cuántos años hace que fuma puros? ___ Años ☐ NR (147-148)

92. ¿Ha fumado alguna vez en pipa? ☐ Si ☐ No (149)

(Si se contesta "Sí" a 92, pregúntese 93 a 95. Si "No," terminese la entrevista.)

93. Fuma en pipa actualmente? ☐ Si ☐ No ☐ NR (150)

(Si se contesta "Sí" a 93, preguntese 94 a 95. Si "No," terminese la entrevista.)

94. ¿Aproximadamente cuántas pipadas de tabaco fuma ordinariamente por día? ___ Número ☐ NR (151-152)

95. ¿Aproximadamente cuántos años hace que fuma en pipa? ___ Años ☐ NR (153-154)

TABLE 1. PREDICTED FVC FOR MALES (KNUDSON, ET AL: AM REV RESPIR DIS. 1976, 113, 587.)

HT \ AGE	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
60.0	3.44	3.59	3.75	3.91	3.72	3.66	3.61	3.55	3.49	3.43	3.37	3.32	3.26	3.20	3.14	3.08	3.03	2.97	2.91	2.85	2.79	2.74	2.68	2.62	2.56
60.5	3.50	3.66	3.81	3.97	3.80	3.75	3.69	3.63	3.57	3.51	3.46	3.40	3.34	3.28	3.22	3.17	3.11	3.05	2.99	2.93	2.88	2.82	2.76	2.70	2.64
61.0	3.56	3.72	3.88	4.03	3.89	3.83	3.77	3.71	3.66	3.60	3.54	3.48	3.42	3.37	3.31	3.25	3.19	3.13	3.08	3.02	2.96	2.90	2.84	2.79	2.73
61.5	3.63	3.78	3.94	4.10	3.97	3.91	3.85	3.80	3.74	3.68	3.62	3.56	3.51	3.45	3.39	3.33	3.27	3.22	3.16	3.10	3.04	2.98	2.93	2.87	2.81
62.0	3.69	3.85	4.00	4.16	4.05	3.99	3.94	3.88	3.82	3.76	3.70	3.65	3.59	3.53	3.47	3.41	3.36	3.30	3.24	3.18	3.12	3.07	3.01	2.95	2.89
62.5	3.76	3.91	4.07	4.22	4.13	4.08	4.02	3.96	3.90	3.84	3.79	3.73	3.67	3.61	3.55	3.50	3.44	3.38	3.32	3.26	3.21	3.15	3.09	3.03	2.97
63.0	3.82	3.97	4.13	4.29	4.22	4.16	4.10	4.04	3.99	3.93	3.87	3.81	3.75	3.70	3.64	3.58	3.52	3.46	3.41	3.35	3.29	3.23	3.17	3.12	3.06
63.5	3.88	4.04	4.19	4.35	4.30	4.24	4.18	4.13	4.07	4.01	3.95	3.89	3.84	3.78	3.72	3.66	3.60	3.55	3.49	3.43	3.37	3.31	3.26	3.20	3.14
64.0	3.95	4.10	4.26	4.41	4.38	4.32	4.27	4.21	4.15	4.09	4.03	3.98	3.92	3.86	3.80	3.74	3.69	3.63	3.57	3.51	3.45	3.40	3.34	3.28	3.22
64.5	4.01	4.17	4.32	4.48	4.46	4.41	4.35	4.29	4.23	4.17	4.12	4.06	4.00	3.94	3.88	3.83	3.77	3.71	3.65	3.59	3.54	3.48	3.42	3.36	3.30
65.0	4.07	4.23	4.39	4.54	4.55	4.49	4.43	4.37	4.32	4.26	4.20	4.14	4.08	4.03	3.97	3.91	3.85	3.79	3.74	3.68	3.62	3.56	3.50	3.45	3.39
65.5	4.14	4.29	4.45	4.60	4.63	4.57	4.51	4.46	4.40	4.34	4.28	4.22	4.17	4.11	4.05	3.99	3.93	3.88	3.82	3.76	3.70	3.64	3.59	3.53	3.47
66.0	4.20	4.36	4.51	4.67	4.71	4.65	4.60	4.54	4.48	4.42	4.36	4.31	4.25	4.19	4.13	4.07	4.02	3.96	3.90	3.84	3.78	3.73	3.67	3.61	3.55
66.5	4.26	4.42	4.58	4.73	4.80	4.74	4.68	4.62	4.56	4.51	4.45	4.39	4.33	4.27	4.22	4.16	4.10	4.04	3.98	3.93	3.87	3.81	3.75	3.69	3.64
67.0	4.33	4.48	4.64	4.80	4.88	4.82	4.76	4.70	4.65	4.59	4.53	4.47	4.41	4.36	4.30	4.24	4.18	4.12	4.07	4.01	3.95	3.89	3.83	3.78	3.72
67.5	4.39	4.55	4.70	4.86	4.96	4.90	4.84	4.79	4.73	4.67	4.61	4.55	4.50	4.44	4.38	4.32	4.26	4.21	4.15	4.09	4.03	3.97	3.92	3.86	3.80
68.0	4.45	4.61	4.77	4.92	5.04	4.98	4.93	4.87	4.81	4.75	4.69	4.64	4.58	4.52	4.46	4.40	4.35	4.29	4.23	4.17	4.11	4.06	4.00	3.94	3.88
68.5	4.52	4.67	4.83	4.99	5.13	5.07	5.01	4.95	4.89	4.84	4.78	4.72	4.66	4.60	4.55	4.49	4.43	4.37	4.31	4.26	4.20	4.14	4.08	4.02	3.97
69.0	4.58	4.74	4.89	5.05	5.21	5.15	5.09	5.03	4.98	4.92	4.86	4.80	4.74	4.69	4.63	4.57	4.51	4.45	4.40	4.34	4.28	4.22	4.16	4.11	4.05
69.5	4.64	4.80	4.96	5.11	5.29	5.23	5.17	5.12	5.06	5.00	4.94	4.88	4.83	4.77	4.71	4.65	4.59	4.54	4.48	4.42	4.36	4.30	4.25	4.19	4.13
70.0	4.71	4.86	5.02	5.18	5.37	5.32	5.26	5.20	5.14	5.08	5.02	4.97	4.91	4.85	4.79	4.74	4.68	4.62	4.56	4.50	4.44	4.39	4.33	4.27	4.21
70.5	4.77	4.93	5.08	5.24	5.46	5.40	5.34	5.28	5.22	5.17	5.11	5.05	4.99	4.93	4.88	4.82	4.76	4.70	4.64	4.59	4.53	4.47	4.41	4.35	4.30
71.0	4.83	4.99	5.15	5.30	5.54	5.48	5.42	5.36	5.31	5.25	5.19	5.13	5.07	5.02	4.96	4.90	4.84	4.78	4.73	4.67	4.61	4.55	4.49	4.44	4.38
71.5	4.90	5.05	5.21	5.37	5.62	5.56	5.50	5.45	5.39	5.33	5.27	5.21	5.16	5.10	5.04	4.98	4.92	4.87	4.81	4.75	4.69	4.63	4.58	4.52	4.46
72.0	4.96	5.12	5.27	5.43	5.70	5.65	5.59	5.53	5.47	5.41	5.36	5.30	5.24	5.18	5.12	5.07	5.01	4.95	4.89	4.83	4.78	4.72	4.66	4.60	4.54
72.5	5.03	5.18	5.34	5.49	5.79	5.73	5.67	5.61	5.55	5.50	5.44	5.38	5.32	5.26	5.21	5.15	5.09	5.03	4.97	4.92	4.86	4.80	4.74	4.68	4.63
73.0	5.09	5.24	5.40	5.56	5.87	5.81	5.75	5.69	5.64	5.58	5.52	5.46	5.40	5.35	5.29	5.23	5.17	5.11	5.06	5.00	4.94	4.88	4.82	4.77	4.71
73.5	5.15	5.31	5.46	5.62	5.95	5.89	5.83	5.78	5.72	5.66	5.60	5.54	5.49	5.43	5.37	5.31	5.25	5.20	5.14	5.08	5.02	4.96	4.91	4.85	4.79
74.0	5.22	5.37	5.53	5.68	6.03	5.98	5.92	5.86	5.80	5.74	5.69	5.63	5.57	5.51	5.45	5.40	5.34	5.28	5.22	5.16	5.11	5.05	4.99	4.93	4.87
74.5	5.28	5.44	5.59	5.75	6.12	6.06	6.00	5.94	5.88	5.83	5.77	5.71	5.65	5.59	5.54	5.48	5.42	5.36	5.30	5.25	5.19	5.13	5.07	5.01	4.96
75.0	5.34	5.50	5.65	5.81	6.20	6.14	6.08	6.02	5.97	5.91	5.85	5.79	5.73	5.68	5.62	5.56	5.50	5.44	5.39	5.33	5.27	5.21	5.15	5.10	5.04
75.5	5.41	5.56	5.72	5.87	6.28	6.22	6.17	6.11	6.05	5.99	5.93	5.88	5.82	5.76	5.70	5.64	5.59	5.53	5.47	5.41	5.35	5.30	5.24	5.18	5.12
76.0	5.47	5.63	5.78	5.94	6.36	6.31	6.25	6.19	6.13	6.07	6.02	5.96	5.90	5.84	5.78	5.73	5.67	5.61	5.55	5.49	5.44	5.38	5.32	5.26	5.20
76.5	5.53	5.69	5.85	6.00	6.45	6.39	6.33	6.27	6.21	6.16	6.10	6.04	5.98	5.92	5.87	5.81	5.75	5.69	5.63	5.58	5.52	5.46	5.40	5.34	5.29
77.0	5.60	5.75	5.91	6.06	6.53	6.47	6.41	6.35	6.30	6.24	6.18	6.12	6.06	6.01	5.95	5.89	5.83	5.77	5.72	5.66	5.60	5.54	5.48	5.43	5.37
77.5	5.66	5.82	5.97	6.13	6.61	6.55	6.50	6.44	6.38	6.32	6.26	6.21	6.15	6.09	6.03	5.97	5.92	5.86	5.80	5.74	5.68	5.63	5.57	5.51	5.45
78.0	5.72	5.88	6.04	6.19	6.69	6.64	6.58	6.52	6.46	6.40	6.35	6.29	6.23	6.17	6.11	6.06	6.00	5.94	5.88	5.82	5.77	5.71	5.65	5.59	5.53
78.5	5.79	5.94	6.10	6.26	6.78	6.72	6.66	6.60	6.54	6.49	6.43	6.37	6.31	6.25	6.20	6.14	6.08	6.02	5.96	5.91	5.85	5.79	5.73	5.67	5.62
79.0	5.85	6.01	6.16	6.32	6.86	6.80	6.74	6.68	6.63	6.57	6.51	6.45	6.39	6.34	6.28	6.22	6.16	6.10	6.05	5.99	5.93	5.87	5.81	5.76	5.70
79.5	5.91	6.07	6.23	6.38	6.94	6.88	6.83	6.77	6.71	6.65	6.59	6.54	6.48	6.42	6.36	6.30	6.25	6.19	6.13	6.07	6.01	5.96	5.90	5.84	5.78
80.0	5.98	6.13	6.29	6.45	7.02	6.97	6.91	6.85	6.79	6.73	6.68	6.62	6.56	6.50	6.44	6.39	6.33	6.27	6.21	6.15	6.10	6.04	5.98	5.92	5.86
80.5	6.04	6.20	6.35	6.51	7.11	7.05	6.99	6.93	6.87	6.82	6.76	6.70	6.64	6.58	6.53	6.47	6.41	6.35	6.29	6.24	6.18	6.12	6.06	6.00	5.95
81.0	6.10	6.26	6.42	6.57	7.19	7.13	7.07	7.02	6.96	6.90	6.84	6.78	6.73	6.67	6.61	6.55	6.49	6.44	6.38	6.32	6.26	6.20	6.15	6.09	6.03
81.5	6.17	6.32	6.48	6.64	7.27	7.21	7.16	7.10	7.04	6.98	6.92	6.87	6.81	6.75	6.69	6.63	6.58	6.52	6.46	6.40	6.34	6.29	6.23	6.17	6.11
82.0	6.23	6.39	6.54	6.70	7.35	7.30	7.24	7.18	7.12	7.06	7.01	6.95	6.89	6.83	6.77	6.72	6.66	6.60	6.54	6.48	6.43	6.37	6.31	6.25	6.19
82.5	6.30	6.45	6.61	6.76	7.44	7.38	7.32	7.26	7.20	7.15	7.09	7.03	6.97	6.91	6.86	6.80	6.74	6.68	6.62	6.57	6.51	6.45	6.39	6.33	6.28
83.0	6.36	6.51	6.67	6.83	7.52	7.46	7.40	7.35	7.29	7.23	7.17	7.11	7.05	7.00	6.94	6.88	6.82	6.77	6.71	6.65	6.59	6.53	6.48	6.42	6.36
83.5	6.42	6.58	6.73	6.89	7.60	7.54	7.49	7.43	7.37	7.31	7.25	7.20	7.14	7.08	7.02	6.96	6.91	6.85	6.79	6.73	6.67	6.62	6.56	6.50	6.44
84.0	6.49	6.64	6.80	6.95	7.68	7.63	7.57	7.51	7.45	7.39	7.34	7.28	7.22	7.16	7.10	7.05	6.99	6.93	6.87	6.81	6.76	6.70	6.64	6.58	6.52
84.5	6.55	6.71	6.86	7.02	7.77	7.71	7.65	7.59	7.53	7.48	7.42	7.36	7.30	7.24	7.19	7.13	7.07	7.01	6.95	6.90	6.84	6.78	6.72	6.66	6.61
85.0	6.61	6.77	6.92	7.08	7.85	7.79	7.73	7.68	7.62	7.56	7.50	7.44	7.39	7.33	7.27	7.21	7.15	7.10	7.04	6.98	6.92	6.86	6.81	6.75	6.69

TABLE 2. PREDICTED FEV1 FOR MALES (KNUDSON, ET AL., AM REV RESPIR DIS. 1976, 113, 587.)

HT	AGE 17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
60.0	2.97	3.06	3.15	3.24	3.05	2.99	2.94	2.88	2.83	2.78	2.72	2.67	2.61	2.56	2.51	2.45	2.40	2.34	2.29	2.24	2.18	2.13	2.07	2.02	1.97
60.5	3.03	3.12	3.21	3.30	3.11	3.06	3.00	2.95	2.90	2.84	2.79	2.73	2.68	2.63	2.57	2.52	2.46	2.41	2.36	2.30	2.25	2.19	2.14	2.09	2.03
61.0	3.08	3.17	3.26	3.35	3.18	3.12	3.07	3.02	2.96	2.91	2.85	2.80	2.75	2.69	2.64	2.58	2.53	2.48	2.42	2.37	2.31	2.26	2.21	2.15	2.10
61.5	3.14	3.23	3.32	3.41	3.24	3.19	3.14	3.08	3.03	2.97	2.92	2.87	2.81	2.76	2.70	2.65	2.60	2.54	2.49	2.43	2.38	2.33	2.27	2.22	2.16
62.0	3.20	3.29	3.38	3.47	3.31	3.26	3.20	3.15	3.09	3.04	2.99	2.93	2.88	2.82	2.77	2.72	2.66	2.61	2.55	2.50	2.45	2.39	2.34	2.28	2.23
62.5	3.26	3.35	3.44	3.53	3.38	3.32	3.27	3.22	3.16	3.11	3.05	3.00	2.95	2.89	2.84	2.78	2.73	2.68	2.62	2.57	2.51	2.46	2.41	2.35	2.30
63.0	3.32	3.41	3.50	3.59	3.44	3.39	3.34	3.28	3.23	3.17	3.12	3.07	3.01	2.96	2.90	2.85	2.80	2.74	2.69	2.63	2.58	2.53	2.47	2.42	2.36
63.5	3.38	3.47	3.56	3.65	3.51	3.46	3.40	3.35	3.29	3.24	3.19	3.13	3.08	3.02	2.97	2.92	2.86	2.81	2.75	2.70	2.65	2.59	2.54	2.48	2.43
64.0	3.43	3.52	3.61	3.70	3.58	3.52	3.47	3.41	3.36	3.31	3.25	3.20	3.14	3.09	3.04	2.98	2.93	2.87	2.82	2.77	2.71	2.66	2.60	2.55	2.50
64.5	3.49	3.58	3.67	3.76	3.64	3.59	3.53	3.48	3.43	3.37	3.32	3.26	3.21	3.16	3.10	3.05	2.99	2.94	2.89	2.83	2.78	2.72	2.67	2.62	2.56
65.0	3.55	3.64	3.73	3.82	3.71	3.65	3.60	3.55	3.49	3.44	3.38	3.33	3.28	3.22	3.17	3.11	3.06	3.01	2.95	2.90	2.84	2.79	2.74	2.68	2.63
65.5	3.61	3.70	3.79	3.88	3.77	3.72	3.67	3.61	3.56	3.50	3.45	3.40	3.34	3.29	3.23	3.18	3.13	3.07	3.02	2.96	2.91	2.86	2.80	2.75	2.69
66.0	3.67	3.76	3.85	3.94	3.84	3.79	3.73	3.68	3.62	3.57	3.52	3.46	3.41	3.35	3.30	3.25	3.19	3.14	3.08	3.03	2.98	2.92	2.87	2.81	2.76
66.5	3.73	3.82	3.91	4.00	3.91	3.85	3.80	3.74	3.69	3.64	3.58	3.53	3.47	3.42	3.37	3.31	3.26	3.20	3.15	3.10	3.04	2.99	2.93	2.88	2.83
67.0	3.79	3.88	3.97	4.06	3.97	3.92	3.86	3.81	3.75	3.70	3.65	3.59	3.54	3.49	3.43	3.38	3.32	3.27	3.22	3.16	3.11	3.05	3.00	2.95	2.89
67.5	3.84	3.93	4.02	4.11	4.04	3.98	3.93	3.88	3.82	3.77	3.71	3.66	3.61	3.55	3.50	3.44	3.39	3.34	3.28	3.23	3.17	3.12	3.07	3.01	2.96
68.0	3.90	3.99	4.08	4.17	4.10	4.05	4.00	3.94	3.89	3.84	3.78	3.73	3.67	3.62	3.56	3.51	3.46	3.40	3.35	3.29	3.24	3.19	3.13	3.08	3.02
68.5	3.96	4.05	4.14	4.23	4.17	4.12	4.06	4.01	3.95	3.90	3.85	3.79	3.74	3.68	3.63	3.58	3.52	3.47	3.41	3.36	3.31	3.25	3.20	3.14	3.09
69.0	4.02	4.11	4.20	4.29	4.24	4.18	4.13	4.07	4.02	3.97	3.91	3.86	3.80	3.75	3.70	3.64	3.59	3.53	3.48	3.43	3.37	3.32	3.26	3.21	3.16
69.5	4.08	4.17	4.26	4.35	4.30	4.25	4.19	4.14	4.09	4.03	3.98	3.92	3.87	3.82	3.76	3.71	3.65	3.60	3.55	3.49	3.44	3.38	3.33	3.28	3.22
70.0	4.14	4.23	4.32	4.41	4.37	4.31	4.26	4.21	4.15	4.10	4.04	3.99	3.94	3.88	3.83	3.77	3.72	3.67	3.61	3.56	3.50	3.45	3.40	3.34	3.29
70.5	4.19	4.28	4.37	4.46	4.43	4.38	4.33	4.27	4.22	4.16	4.11	4.06	4.00	3.95	3.89	3.84	3.79	3.73	3.68	3.62	3.57	3.52	3.46	3.41	3.35
71.0	4.25	4.34	4.43	4.52	4.50	4.45	4.39	4.34	4.28	4.23	4.18	4.12	4.07	4.01	3.96	3.91	3.85	3.80	3.74	3.69	3.64	3.58	3.53	3.47	3.42
71.5	4.31	4.40	4.49	4.58	4.57	4.51	4.46	4.40	4.35	4.30	4.24	4.19	4.13	4.08	4.03	3.97	3.92	3.86	3.81	3.76	3.70	3.65	3.59	3.54	3.49
72.0	4.37	4.46	4.55	4.64	4.63	4.58	4.52	4.47	4.42	4.36	4.31	4.25	4.20	4.15	4.09	4.04	3.98	3.93	3.88	3.82	3.77	3.71	3.66	3.61	3.55
72.5	4.43	4.52	4.61	4.70	4.70	4.64	4.59	4.54	4.48	4.43	4.37	4.32	4.27	4.21	4.16	4.10	4.05	4.00	3.94	3.89	3.83	3.78	3.73	3.67	3.62
73.0	4.49	4.58	4.67	4.76	4.76	4.71	4.66	4.60	4.55	4.49	4.44	4.39	4.33	4.28	4.22	4.17	4.12	4.06	4.01	3.95	3.90	3.85	3.79	3.74	3.68
73.5	4.54	4.63	4.72	4.81	4.83	4.78	4.72	4.67	4.61	4.56	4.51	4.45	4.40	4.34	4.29	4.24	4.18	4.13	4.07	4.02	3.97	3.91	3.86	3.80	3.75
74.0	4.60	4.69	4.78	4.87	4.90	4.84	4.79	4.73	4.68	4.63	4.57	4.52	4.46	4.41	4.36	4.30	4.25	4.19	4.14	4.09	4.03	3.98	3.92	3.87	3.82
74.5	4.66	4.75	4.84	4.93	4.96	4.91	4.85	4.80	4.75	4.69	4.64	4.58	4.53	4.48	4.42	4.37	4.31	4.26	4.21	4.15	4.10	4.04	3.99	3.94	3.88
75.0	4.72	4.81	4.90	4.99	5.03	4.97	4.92	4.87	4.81	4.76	4.70	4.65	4.60	4.54	4.49	4.43	4.38	4.33	4.27	4.22	4.16	4.11	4.06	4.00	3.95
75.5	4.78	4.87	4.96	5.05	5.09	5.04	4.99	4.93	4.88	4.82	4.77	4.72	4.66	4.61	4.55	4.50	4.45	4.39	4.34	4.28	4.23	4.18	4.12	4.07	4.01
76.0	4.84	4.93	5.02	5.11	5.16	5.11	5.05	5.00	4.94	4.89	4.84	4.78	4.73	4.67	4.62	4.57	4.51	4.46	4.40	4.35	4.30	4.24	4.19	4.13	4.08
76.5	4.90	4.99	5.08	5.17	5.23	5.17	5.12	5.06	5.01	4.96	4.90	4.85	4.79	4.74	4.69	4.63	4.58	4.52	4.47	4.42	4.36	4.31	4.25	4.20	4.15
77.0	4.95	5.04	5.13	5.22	5.29	5.24	5.18	5.13	5.08	5.02	4.97	4.91	4.86	4.81	4.75	4.70	4.64	4.59	4.54	4.48	4.43	4.37	4.32	4.27	4.21
77.5	5.01	5.10	5.19	5.28	5.36	5.30	5.25	5.20	5.14	5.09	5.03	4.98	4.93	4.87	4.82	4.76	4.71	4.66	4.60	4.55	4.49	4.44	4.39	4.33	4.28
78.0	5.07	5.16	5.25	5.34	5.42	5.37	5.32	5.26	5.21	5.15	5.10	5.05	4.99	4.94	4.88	4.83	4.78	4.72	4.67	4.61	4.56	4.51	4.45	4.40	4.34
78.5	5.13	5.22	5.31	5.40	5.49	5.44	5.38	5.33	5.27	5.22	5.17	5.11	5.06	5.00	4.95	4.90	4.84	4.79	4.73	4.68	4.63	4.57	4.52	4.46	4.41
79.0	5.19	5.28	5.37	5.46	5.56	5.50	5.45	5.39	5.34	5.29	5.23	5.18	5.12	5.07	5.02	4.96	4.91	4.85	4.80	4.75	4.69	4.64	4.58	4.53	4.48
79.5	5.25	5.34	5.43	5.52	5.62	5.57	5.51	5.46	5.41	5.35	5.30	5.24	5.19	5.14	5.08	5.03	4.97	4.92	4.87	4.81	4.76	4.70	4.65	4.60	4.54
80.0	5.30	5.39	5.48	5.57	5.69	5.63	5.58	5.53	5.47	5.42	5.36	5.31	5.26	5.20	5.15	5.09	5.04	4.99	4.93	4.88	4.82	4.77	4.72	4.66	4.61
80.5	5.36	5.45	5.54	5.63	5.75	5.70	5.65	5.59	5.54	5.48	5.43	5.38	5.32	5.27	5.21	5.16	5.11	5.05	5.00	4.94	4.89	4.84	4.78	4.73	4.67
81.0	5.42	5.51	5.60	5.69	5.82	5.77	5.71	5.66	5.60	5.55	5.50	5.44	5.39	5.33	5.28	5.23	5.17	5.12	5.06	5.01	4.96	4.90	4.85	4.79	4.74
81.5	5.48	5.57	5.66	5.75	5.89	5.83	5.78	5.72	5.67	5.62	5.56	5.51	5.45	5.40	5.35	5.29	5.24	5.18	5.13	5.08	5.02	4.97	4.91	4.86	4.81
82.0	5.54	5.63	5.72	5.81	5.95	5.90	5.84	5.79	5.74	5.68	5.63	5.57	5.52	5.47	5.41	5.36	5.30	5.25	5.20	5.14	5.09	5.03	4.98	4.93	4.87
82.5	5.60	5.69	5.78	5.87	6.02	5.96	5.91	5.86	5.80	5.75	5.69	5.64	5.59	5.53	5.48	5.42	5.37	5.32	5.26	5.21	5.15	5.10	5.05	4.99	4.94
83.0	5.65	5.74	5.83	5.92	6.08	6.03	5.98	5.92	5.87	5.81	5.76	5.71	5.65	5.60	5.54	5.49	5.44	5.38	5.33	5.27	5.22	5.17	5.11	5.06	5.00
83.5	5.71	5.80	5.89	5.98	6.15	6.10	6.04	5.99	5.93	5.88	5.83	5.77	5.72	5.66	5.61	5.56	5.50	5.45	5.39	5.34	5.29	5.23	5.18	5.12	5.07
84.0	5.77	5.86	5.95	6.04	6.22	6.16	6.11	6.05	6.00	5.95	5.89	5.84	5.78	5.73	5.68	5.62	5.57	5.51	5.46	5.41	5.35	5.30	5.24	5.19	5.14
84.5	5.83	5.92	6.01	6.10	6.28	6.23	6.17	6.12	6.07	6.01	5.96	5.90	5.85	5.80	5.74	5.69	5.63	5.58	5.53	5.47	5.42	5.36	5.31	5.26	5.20
85.0	5.89	5.98	6.07	6.16	6.35	6.29	6.24	6.19	6.13	6.08	6.02	5.97	5.92	5.86	5.81	5.75	5.70	5.65	5.59	5.54	5.48	5.43	5.38	5.32	5.27

TABLE 3. PREDICTED FVC FOR FEMALES (KNUDSON, ET AL: AM REV RESPIR DIS. 1976. 113. 587.)

HT	AGE 17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
52.0	2.45	2.64	2.65	2.61	2.56	2.52	2.47	2.43	2.39	2.34	2.30	2.25	2.21	2.17	2.12	2.08	2.03	1.99	1.95	1.90	1.86	1.81	1.77	1.73	1.68
52.5	2.50	2.68	2.70	2.65	2.61	2.57	2.52	2.48	2.43	2.39	2.35	2.30	2.26	2.21	2.17	2.13	2.08	2.04	1.99	1.95	1.91	1.86	1.82	1.77	1.73
53.0	2.54	2.72	2.74	2.70	2.66	2.61	2.57	2.52	2.48	2.44	2.39	2.35	2.30	2.26	2.22	2.17	2.13	2.08	2.04	2.00	1.95	1.91	1.86	1.82	1.78
53.5	2.58	2.76	2.79	2.75	2.70	2.66	2.62	2.57	2.53	2.48	2.44	2.40	2.35	2.31	2.26	2.22	2.18	2.13	2.09	2.04	2.00	1.96	1.91	1.87	1.82
54.0	2.62	2.81	2.84	2.79	2.75	2.71	2.66	2.62	2.57	2.53	2.49	2.44	2.40	2.35	2.31	2.27	2.22	2.18	2.13	2.09	2.05	2.00	1.96	1.91	1.87
54.5	2.66	2.85	2.89	2.84	2.80	2.75	2.71	2.67	2.62	2.58	2.53	2.49	2.45	2.40	2.36	2.31	2.27	2.23	2.18	2.14	2.09	2.05	2.01	1.96	1.92
55.0	2.71	2.89	2.93	2.89	2.84	2.80	2.76	2.71	2.67	2.62	2.58	2.54	2.49	2.45	2.40	2.36	2.32	2.27	2.23	2.18	2.14	2.10	2.05	2.01	1.96
55.5	2.75	2.93	2.98	2.94	2.89	2.85	2.80	2.76	2.72	2.67	2.63	2.58	2.54	2.50	2.45	2.41	2.36	2.32	2.28	2.23	2.19	2.14	2.10	2.06	2.01
56.0	2.79	2.98	3.03	2.98	2.94	2.89	2.85	2.81	2.76	2.72	2.67	2.63	2.59	2.54	2.50	2.45	2.41	2.37	2.32	2.28	2.23	2.19	2.15	2.10	2.06
56.5	2.83	3.02	3.07	3.03	2.99	2.94	2.90	2.85	2.81	2.77	2.72	2.68	2.63	2.59	2.55	2.50	2.46	2.41	2.37	2.33	2.28	2.24	2.19	2.15	2.11
57.0	2.87	3.06	3.12	3.08	3.03	2.99	2.94	2.90	2.86	2.81	2.77	2.72	2.68	2.64	2.59	2.55	2.50	2.46	2.42	2.37	2.33	2.28	2.24	2.20	2.15
57.5	2.91	3.10	3.17	3.12	3.08	3.04	2.99	2.95	2.90	2.86	2.82	2.77	2.73	2.68	2.64	2.60	2.55	2.51	2.46	2.42	2.38	2.33	2.29	2.24	2.20
58.0	2.96	3.14	3.21	3.17	3.13	3.08	3.04	2.99	2.95	2.91	2.86	2.82	2.77	2.73	2.69	2.64	2.60	2.55	2.51	2.47	2.42	2.38	2.33	2.29	2.25
58.5	3.00	3.18	3.26	3.22	3.17	3.13	3.09	3.04	3.00	2.95	2.91	2.87	2.82	2.78	2.73	2.69	2.65	2.60	2.56	2.51	2.47	2.43	2.38	2.34	2.29
59.0	3.04	3.22	3.31	3.26	3.22	3.18	3.13	3.09	3.04	3.00	2.96	2.91	2.87	2.82	2.78	2.74	2.69	2.65	2.60	2.56	2.52	2.47	2.43	2.38	2.34
59.5	3.08	3.27	3.36	3.31	3.27	3.22	3.18	3.14	3.09	3.05	3.00	2.96	2.92	2.87	2.83	2.78	2.74	2.70	2.65	2.61	2.56	2.52	2.48	2.43	2.39
60.0	3.12	3.31	3.40	3.36	3.31	3.27	3.23	3.18	3.14	3.09	3.05	3.01	2.96	2.92	2.87	2.83	2.79	2.74	2.70	2.65	2.61	2.57	2.52	2.48	2.43
60.5	3.17	3.35	3.45	3.41	3.36	3.32	3.27	3.23	3.19	3.14	3.10	3.05	3.01	2.97	2.92	2.88	2.83	2.79	2.75	2.70	2.66	2.61	2.57	2.53	2.48
61.0	3.21	3.39	3.50	3.45	3.41	3.36	3.32	3.28	3.23	3.19	3.14	3.10	3.06	3.01	2.97	2.92	2.88	2.84	2.79	2.75	2.70	2.66	2.62	2.57	2.53
61.5	3.25	3.43	3.54	3.50	3.46	3.41	3.37	3.32	3.28	3.24	3.19	3.15	3.10	3.06	3.02	2.97	2.93	2.88	2.84	2.80	2.75	2.71	2.66	2.62	2.58
62.0	3.29	3.48	3.59	3.55	3.50	3.46	3.41	3.37	3.33	3.28	3.24	3.19	3.15	3.11	3.06	3.02	2.97	2.93	2.89	2.84	2.80	2.75	2.71	2.67	2.62
62.5	3.33	3.52	3.64	3.59	3.55	3.51	3.46	3.42	3.37	3.33	3.29	3.24	3.20	3.15	3.11	3.07	3.02	2.98	2.93	2.89	2.85	2.80	2.76	2.71	2.67
63.0	3.38	3.56	3.68	3.64	3.60	3.55	3.51	3.46	3.42	3.38	3.33	3.29	3.24	3.20	3.16	3.11	3.07	3.02	2.98	2.94	2.89	2.85	2.80	2.76	2.72
63.5	3.42	3.60	3.73	3.69	3.64	3.60	3.56	3.51	3.47	3.42	3.38	3.34	3.29	3.25	3.20	3.16	3.12	3.07	3.03	2.98	2.94	2.90	2.85	2.81	2.76
64.0	3.46	3.64	3.78	3.73	3.69	3.65	3.60	3.56	3.51	3.47	3.43	3.38	3.34	3.29	3.25	3.21	3.16	3.12	3.07	3.03	2.99	2.94	2.90	2.85	2.81
64.5	3.50	3.69	3.83	3.78	3.74	3.69	3.65	3.61	3.56	3.52	3.47	3.43	3.39	3.34	3.30	3.25	3.21	3.17	3.12	3.08	3.03	2.99	2.95	2.90	2.86
65.0	3.54	3.73	3.87	3.83	3.78	3.74	3.70	3.65	3.61	3.56	3.52	3.48	3.43	3.39	3.34	3.30	3.26	3.21	3.17	3.12	3.08	3.04	2.99	2.95	2.90
65.5	3.59	3.77	3.92	3.88	3.83	3.79	3.74	3.70	3.66	3.61	3.57	3.52	3.48	3.44	3.39	3.35	3.30	3.26	3.22	3.17	3.13	3.08	3.04	3.00	2.95
66.0	3.63	3.81	3.97	3.92	3.88	3.83	3.79	3.75	3.70	3.66	3.61	3.57	3.53	3.48	3.44	3.39	3.35	3.31	3.26	3.22	3.17	3.13	3.09	3.04	3.00
66.5	3.67	3.85	4.01	3.97	3.93	3.88	3.84	3.79	3.75	3.71	3.66	3.62	3.57	3.53	3.49	3.44	3.40	3.35	3.31	3.27	3.22	3.18	3.13	3.09	3.05
67.0	3.71	3.89	4.06	4.02	3.97	3.93	3.88	3.84	3.80	3.75	3.71	3.66	3.62	3.58	3.53	3.49	3.44	3.40	3.36	3.31	3.27	3.22	3.18	3.14	3.09
67.5	3.75	3.94	4.11	4.06	4.02	3.98	3.93	3.89	3.84	3.80	3.76	3.71	3.67	3.62	3.58	3.54	3.49	3.45	3.40	3.36	3.32	3.27	3.23	3.18	3.14
68.0	3.79	3.98	4.15	4.11	4.07	4.02	3.98	3.93	3.89	3.85	3.80	3.76	3.71	3.67	3.63	3.58	3.54	3.49	3.45	3.41	3.36	3.32	3.27	3.23	3.19
68.5	3.84	4.02	4.20	4.16	4.11	4.07	4.03	3.98	3.94	3.89	3.85	3.81	3.76	3.72	3.67	3.63	3.59	3.54	3.50	3.45	3.41	3.37	3.32	3.28	3.23
69.0	3.88	4.06	4.25	4.20	4.16	4.12	4.07	4.03	3.98	3.94	3.90	3.85	3.81	3.76	3.72	3.68	3.63	3.59	3.54	3.50	3.46	3.41	3.37	3.32	3.28
69.5	3.92	4.10	4.30	4.25	4.21	4.16	4.12	4.08	4.03	3.99	3.94	3.90	3.86	3.81	3.77	3.72	3.68	3.64	3.59	3.55	3.50	3.46	3.42	3.37	3.33
70.0	3.96	4.15	4.34	4.30	4.25	4.21	4.17	4.12	4.08	4.03	3.99	3.95	3.90	3.86	3.81	3.77	3.73	3.68	3.64	3.59	3.55	3.51	3.46	3.42	3.37
70.5	4.00	4.19	4.39	4.35	4.30	4.26	4.21	4.17	4.13	4.08	4.04	3.99	3.95	3.91	3.86	3.82	3.77	3.73	3.69	3.64	3.60	3.55	3.51	3.47	3.42
71.0	4.05	4.23	4.44	4.39	4.35	4.30	4.26	4.22	4.17	4.13	4.08	4.04	4.00	3.95	3.91	3.86	3.82	3.78	3.73	3.69	3.64	3.60	3.56	3.51	3.47
71.5	4.09	4.27	4.48	4.44	4.40	4.35	4.31	4.26	4.22	4.18	4.13	4.09	4.04	4.00	3.96	3.91	3.87	3.82	3.78	3.74	3.69	3.65	3.60	3.56	3.52
72.0	4.13	4.31	4.53	4.49	4.44	4.40	4.35	4.31	4.27	4.22	4.18	4.13	4.09	4.05	4.00	3.96	3.91	3.87	3.83	3.78	3.74	3.69	3.65	3.61	3.56
72.5	4.17	4.36	4.58	4.53	4.49	4.45	4.40	4.36	4.31	4.27	4.23	4.18	4.14	4.09	4.05	4.01	3.96	3.92	3.87	3.83	3.79	3.74	3.70	3.65	3.61
73.0	4.21	4.40	4.62	4.58	4.54	4.49	4.45	4.40	4.36	4.32	4.27	4.23	4.18	4.14	4.10	4.05	4.01	3.96	3.92	3.88	3.83	3.79	3.74	3.70	3.66
73.5	4.26	4.44	4.67	4.63	4.58	4.54	4.50	4.45	4.41	4.36	4.32	4.28	4.23	4.19	4.14	4.10	4.06	4.01	3.97	3.92	3.88	3.84	3.79	3.75	3.70
74.0	4.30	4.48	4.72	4.67	4.63	4.59	4.54	4.50	4.45	4.41	4.37	4.32	4.28	4.23	4.19	4.15	4.10	4.06	4.01	3.97	3.93	3.88	3.84	3.79	3.75
74.5	4.34	4.52	4.77	4.72	4.68	4.63	4.59	4.55	4.50	4.46	4.41	4.37	4.33	4.28	4.24	4.19	4.15	4.11	4.06	4.02	3.97	3.93	3.89	3.84	3.80
75.0	4.38	4.57	4.81	4.77	4.72	4.68	4.64	4.59	4.55	4.50	4.46	4.42	4.37	4.33	4.28	4.24	4.20	4.15	4.11	4.06	4.02	3.98	3.93	3.89	3.84
75.5	4.42	4.61	4.86	4.82	4.77	4.73	4.68	4.64	4.60	4.55	4.51	4.46	4.42	4.38	4.33	4.29	4.24	4.20	4.16	4.11	4.07	4.02	3.98	3.94	3.89
76.0	4.47	4.65	4.91	4.86	4.82	4.77	4.73	4.69	4.64	4.60	4.55	4.51	4.47	4.42	4.38	4.33	4.29	4.25	4.20	4.16	4.11	4.07	4.03	3.98	3.94
76.5	4.51	4.69	4.95	4.91	4.87	4.82	4.78	4.73	4.69	4.65	4.60	4.56	4.51	4.47	4.43	4.38	4.34	4.29	4.25	4.21	4.16	4.12	4.07	4.03	3.99
77.0	4.55	4.73	5.00	4.96	4.91	4.87	4.82	4.78	4.74	4.69	4.65	4.60	4.56	4.52	4.47	4.43	4.38	4.34	4.30	4.25	4.21	4.16	4.12	4.08	4.03

TABLE 4. PREDICTED FEV1 FOR FEMALES (KNUDSON, ET AL: AM REV RESPIR DIS. 1976. 113. 587.)

HT	AGE 17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
52.0	2.31	2.48	2.33	2.29	2.25	2.21	2.16	2.12	2.08	2.04	2.00	1.95	1.91	1.87	1.83	1.79	1.74	1.70	1.66	1.62	1.58	1.53	1.49	1.45	1.41
52.5	2.34	2.51	2.37	2.32	2.28	2.24	2.20	2.16	2.11	2.07	2.03	1.99	1.95	1.90	1.86	1.82	1.78	1.74	1.69	1.65	1.61	1.57	1.53	1.48	1.44
53.0	2.38	2.55	2.40	2.36	2.32	2.27	2.23	2.19	2.15	2.11	2.06	2.02	1.98	1.94	1.90	1.85	1.81	1.77	1.73	1.69	1.64	1.60	1.56	1.52	1.48
53.5	2.41	2.58	2.43	2.39	2.35	2.31	2.27	2.22	2.18	2.14	2.10	2.06	2.01	1.97	1.93	1.89	1.85	1.80	1.76	1.72	1.68	1.64	1.59	1.55	1.51
54.0	2.45	2.62	2.47	2.43	2.38	2.34	2.30	2.26	2.22	2.17	2.13	2.09	2.05	2.01	1.96	1.92	1.88	1.84	1.80	1.75	1.71	1.67	1.63	1.59	1.54
54.5	2.48	2.65	2.50	2.46	2.42	2.38	2.33	2.29	2.25	2.21	2.17	2.12	2.08	2.04	2.00	1.96	1.91	1.87	1.83	1.79	1.75	1.70	1.66	1.62	1.58
55.0	2.51	2.68	2.54	2.49	2.45	2.41	2.37	2.33	2.28	2.24	2.20	2.16	2.12	2.07	2.03	1.99	1.95	1.91	1.86	1.82	1.78	1.74	1.70	1.65	1.61
55.5	2.55	2.72	2.57	2.53	2.49	2.45	2.40	2.36	2.32	2.28	2.24	2.19	2.15	2.11	2.07	2.03	1.98	1.94	1.90	1.86	1.82	1.77	1.73	1.69	1.65
56.0	2.58	2.75	2.61	2.56	2.52	2.48	2.44	2.40	2.35	2.31	2.27	2.23	2.19	2.14	2.10	2.06	2.02	1.98	1.93	1.89	1.85	1.81	1.77	1.72	1.68
56.5	2.62	2.79	2.64	2.60	2.56	2.51	2.47	2.43	2.39	2.35	2.30	2.26	2.22	2.18	2.14	2.09	2.05	2.01	1.97	1.93	1.88	1.84	1.80	1.76	1.72
57.0	2.65	2.82	2.67	2.63	2.59	2.55	2.51	2.46	2.42	2.38	2.34	2.30	2.25	2.21	2.17	2.13	2.09	2.04	2.00	1.96	1.92	1.88	1.83	1.79	1.75
57.5	2.69	2.86	2.71	2.67	2.62	2.58	2.54	2.50	2.46	2.41	2.37	2.33	2.29	2.25	2.20	2.16	2.12	2.08	2.04	1.99	1.95	1.91	1.87	1.83	1.78
58.0	2.72	2.89	2.74	2.70	2.66	2.62	2.57	2.53	2.49	2.45	2.41	2.36	2.32	2.28	2.24	2.20	2.15	2.11	2.07	2.03	1.99	1.94	1.90	1.86	1.82
58.5	2.75	2.92	2.78	2.73	2.69	2.65	2.61	2.57	2.52	2.48	2.44	2.40	2.36	2.31	2.27	2.23	2.19	2.15	2.10	2.06	2.02	1.98	1.94	1.89	1.85
59.0	2.79	2.96	2.81	2.77	2.73	2.69	2.64	2.60	2.56	2.52	2.48	2.43	2.39	2.35	2.31	2.27	2.22	2.18	2.14	2.10	2.06	2.01	1.97	1.93	1.89
59.5	2.82	2.99	2.85	2.80	2.76	2.72	2.68	2.64	2.59	2.55	2.51	2.47	2.43	2.38	2.34	2.30	2.26	2.22	2.17	2.13	2.09	2.05	2.01	1.96	1.92
60.0	2.86	3.03	2.88	2.84	2.80	2.75	2.71	2.67	2.63	2.59	2.54	2.50	2.46	2.42	2.38	2.33	2.29	2.25	2.21	2.17	2.12	2.08	2.04	2.00	1.96
60.5	2.89	3.06	2.91	2.87	2.83	2.79	2.75	2.70	2.66	2.62	2.58	2.54	2.49	2.45	2.41	2.37	2.33	2.28	2.24	2.20	2.16	2.12	2.07	2.03	1.99
61.0	2.93	3.10	2.95	2.91	2.86	2.82	2.78	2.74	2.70	2.65	2.61	2.57	2.53	2.49	2.44	2.40	2.36	2.32	2.28	2.23	2.19	2.15	2.11	2.07	2.02
61.5	2.96	3.13	2.98	2.94	2.90	2.86	2.81	2.77	2.73	2.69	2.65	2.60	2.56	2.52	2.48	2.44	2.39	2.35	2.31	2.27	2.23	2.18	2.14	2.10	2.06
62.0	2.99	3.16	3.02	2.97	2.93	2.89	2.85	2.81	2.76	2.72	2.68	2.64	2.60	2.55	2.51	2.47	2.43	2.39	2.34	2.30	2.26	2.22	2.18	2.13	2.09
62.5	3.03	3.20	3.05	3.01	2.97	2.93	2.88	2.84	2.80	2.76	2.72	2.67	2.63	2.59	2.55	2.51	2.46	2.42	2.38	2.34	2.30	2.25	2.21	2.17	2.13
63.0	3.06	3.23	3.09	3.04	3.00	2.96	2.92	2.88	2.83	2.79	2.75	2.71	2.67	2.62	2.58	2.54	2.50	2.46	2.41	2.37	2.33	2.29	2.25	2.20	2.16
63.5	3.10	3.27	3.12	3.08	3.04	2.99	2.95	2.91	2.87	2.83	2.78	2.74	2.70	2.66	2.62	2.57	2.53	2.49	2.45	2.41	2.36	2.32	2.28	2.24	2.20
64.0	3.13	3.30	3.15	3.11	3.07	3.03	2.99	2.94	2.90	2.86	2.82	2.78	2.73	2.69	2.65	2.61	2.57	2.52	2.48	2.44	2.40	2.36	2.31	2.27	2.23
64.5	3.17	3.34	3.19	3.15	3.10	3.06	3.02	2.98	2.94	2.89	2.85	2.81	2.77	2.73	2.68	2.64	2.60	2.56	2.52	2.47	2.43	2.39	2.35	2.31	2.26
65.0	3.20	3.37	3.22	3.18	3.14	3.10	3.05	3.01	2.97	2.93	2.89	2.84	2.80	2.76	2.72	2.68	2.63	2.59	2.55	2.51	2.47	2.42	2.38	2.34	2.30
65.5	3.23	3.40	3.26	3.21	3.17	3.13	3.09	3.05	3.00	2.96	2.92	2.88	2.84	2.79	2.75	2.71	2.67	2.63	2.58	2.54	2.50	2.46	2.42	2.37	2.33
66.0	3.27	3.44	3.29	3.25	3.21	3.17	3.12	3.08	3.04	3.00	2.96	2.91	2.87	2.83	2.79	2.75	2.70	2.66	2.62	2.58	2.54	2.49	2.45	2.41	2.37
66.5	3.30	3.47	3.33	3.28	3.24	3.20	3.16	3.12	3.07	3.03	2.99	2.95	2.91	2.86	2.82	2.78	2.74	2.70	2.65	2.61	2.57	2.53	2.49	2.44	2.40
67.0	3.34	3.51	3.36	3.32	3.28	3.23	3.19	3.15	3.11	3.07	3.02	2.98	2.94	2.90	2.86	2.81	2.77	2.73	2.69	2.65	2.60	2.56	2.52	2.48	2.44
67.5	3.37	3.54	3.39	3.35	3.31	3.27	3.23	3.18	3.14	3.10	3.06	3.02	2.97	2.93	2.89	2.85	2.81	2.76	2.72	2.68	2.64	2.60	2.55	2.51	2.47
68.0	3.41	3.58	3.43	3.39	3.34	3.30	3.26	3.22	3.18	3.13	3.09	3.05	3.01	2.96	2.92	2.88	2.84	2.80	2.76	2.71	2.67	2.63	2.59	2.55	2.50
68.5	3.44	3.61	3.46	3.42	3.38	3.34	3.29	3.25	3.21	3.17	3.13	3.08	3.04	3.00	2.96	2.92	2.87	2.83	2.79	2.75	2.71	2.66	2.62	2.58	2.54
69.0	3.47	3.64	3.50	3.46	3.41	3.37	3.33	3.29	3.25	3.20	3.16	3.12	3.08	3.04	2.99	2.95	2.91	2.87	2.83	2.78	2.74	2.70	2.66	2.62	2.57
69.5	3.51	3.68	3.53	3.49	3.45	3.41	3.36	3.32	3.28	3.24	3.20	3.15	3.11	3.07	3.03	2.99	2.94	2.90	2.86	2.82	2.78	2.73	2.69	2.65	2.61
70.0	3.54	3.71	3.57	3.52	3.48	3.44	3.40	3.36	3.31	3.27	3.23	3.19	3.15	3.10	3.06	3.02	2.98	2.94	2.89	2.85	2.81	2.77	2.73	2.68	2.64
70.5	3.58	3.75	3.60	3.56	3.52	3.47	3.43	3.39	3.35	3.31	3.26	3.22	3.18	3.14	3.10	3.05	3.01	2.97	2.93	2.89	2.84	2.80	2.76	2.72	2.68
71.0	3.61	3.78	3.63	3.59	3.55	3.51	3.47	3.42	3.38	3.34	3.30	3.26	3.21	3.17	3.13	3.09	3.05	3.00	2.96	2.92	2.88	2.84	2.79	2.75	2.71
71.5	3.65	3.82	3.67	3.63	3.58	3.54	3.50	3.46	3.42	3.37	3.33	3.29	3.25	3.21	3.16	3.12	3.08	3.04	3.00	2.95	2.91	2.87	2.83	2.79	2.74
72.0	3.68	3.85	3.70	3.66	3.62	3.58	3.53	3.49	3.45	3.41	3.37	3.32	3.28	3.24	3.20	3.16	3.11	3.07	3.03	2.99	2.95	2.90	2.86	2.82	2.78
72.5	3.71	3.88	3.74	3.70	3.65	3.61	3.57	3.53	3.49	3.44	3.40	3.36	3.32	3.28	3.23	3.19	3.15	3.11	3.07	3.02	2.98	2.94	2.90	2.86	2.81
73.0	3.75	3.92	3.77	3.73	3.69	3.65	3.60	3.56	3.52	3.48	3.44	3.39	3.35	3.31	3.27	3.23	3.18	3.14	3.10	3.06	3.02	2.97	2.93	2.89	2.85
73.5	3.78	3.95	3.81	3.76	3.72	3.68	3.64	3.60	3.55	3.51	3.47	3.43	3.39	3.34	3.30	3.26	3.22	3.18	3.13	3.09	3.05	3.01	2.97	2.92	2.88
74.0	3.82	3.99	3.84	3.80	3.76	3.71	3.67	3.63	3.59	3.55	3.50	3.46	3.42	3.38	3.34	3.29	3.25	3.21	3.17	3.13	3.08	3.04	3.00	2.96	2.92
74.5	3.85	4.02	3.87	3.83	3.79	3.75	3.71	3.66	3.62	3.58	3.54	3.50	3.45	3.41	3.37	3.33	3.29	3.24	3.20	3.16	3.12	3.08	3.03	2.99	2.95
75.0	3.89	4.06	3.91	3.87	3.82	3.78	3.74	3.70	3.66	3.61	3.57	3.53	3.49	3.45	3.40	3.36	3.32	3.28	3.24	3.19	3.15	3.11	3.07	3.03	2.98
75.5	3.92	4.09	3.94	3.90	3.86	3.82	3.77	3.73	3.69	3.65	3.61	3.56	3.52	3.48	3.44	3.40	3.35	3.31	3.27	3.23	3.19	3.14	3.10	3.06	3.02
76.0	3.95	4.12	3.98	3.94	3.89	3.85	3.81	3.77	3.73	3.68	3.64	3.60	3.56	3.52	3.47	3.43	3.39	3.35	3.31	3.26	3.22	3.18	3.14	3.10	3.05
76.5	3.99	4.16	4.01	3.97	3.93	3.89	3.84	3.80	3.76	3.72	3.68	3.63	3.59	3.55	3.51	3.47	3.42	3.38	3.34	3.30	3.26	3.21	3.17	3.13	3.09
77.0	4.02	4.19	4.05	4.00	3.96	3.92	3.88	3.84	3.79	3.75	3.71	3.67	3.63	3.58	3.54	3.50	3.46	3.42	3.37	3.33	3.29	3.25	3.21	3.16	3.12

APPENDIX D—PULMONARY FUNCTION STANDARDS FOR COTTON DUST STANDARD

The spirometric measurements of pulmonary function shall conform to the following minimum standards, and these standards are not intended to preclude additional testing or alternate methods which can be determined to be superior.

I. APPARATUS

a. The instrument shall be accurate to within ±50 milliliters or within ±3 percent of reading, whichever is greater.

b. The instrument should be capable of measuring vital capacity from 0 to 7 liters BTPS.

c. The instrument shall have a low inertia and offer low resistance to airflow such that the resistance to airflow at 12 liters per second must be less than 1.5 cm H_2O/(liter/sec).

d. The zero time point for the purpose of timing the FEV_1 shall be determined by extrapolating the steepest portion of the volume time curve back to the maximal inspiration volume (1, 2, 3, 4) or by an equivalent method.

e. Instruments incorporating measurements of airflow to determine volume shall conform to the same volume accuracy stated in (a) of this section when presented with flow rates from at least 0 to 12 liters per second.

f. The instrument or user of the instrument must have a means of correcting volumes to body temperature saturated with water vapor (BTPS) under conditions of varying ambient spirometer temperatures and barometric pressures.

g. The instrument used shall provide a tracing or display of either flow versus volume or volume versus time during the entire forced expiration. A tracing or display is necessary to determine whether the patient has performed the test properly. The tracing must be stored and available for recall and must be of sufficient size that hand measurements may be made within requirement of paragraph (a) of this section. If a paper record is made it must have a paper speed of at least 2 cm/sec and a volume sensitivity of at least 10.0 mm of chart per liter of volume.

h. The instrument shall be capable of accumulating for a minimum of 10 seconds and shall not stop accumulating volume before (1) the volume change for a 0.5 second interval is less than 25 milliliters, or (2) the flow is less than 50 milliliters per second for a 0.5 second interval.

i. The forced vital capacity (FVC) and forced expiratory volume in 1 second ($FEV^{1.0}$) measurements shall comply with the accuracy requirements stated in paragraph (a) of this section. That is, they should be accurately measured to within ±50 ml or within ±3 percent of reading, whichever is greater.

j. The instrument must be capable of being calibrated in the field with respect to the FEV_1 and FVC. This calibration of the FEV_1 and FVC may be either directly or indirectly through volume and time base measurements. The volume calibration source should provide a volume displacement of at least 2 liters and should be accurate to within ±30 milliliters.

II. TECHNIQUE FOR MEASUREMENT OF FORCED VITAL CAPACITY MANEUVER

a. Use of a nose clip is recommended but not required. The procedures shall be explained in simple terms to the patient who shall be instructed to loosen any tight clothing and stand in front of the apparatus. The subject may sit, but care should be taken on repeat testing that the same position be used and, if possible, the same spirometer. Particular attention shall be given to insure that the chin is slightly elevated with the neck slightly extended. The patient shall be instructed to make a full inspiration from a normal breathing pattern and then blow into the apparatus, without interruption, as hard, fast, and completely as possible. At least three forced expirations shall be carried out. During the maneuvers, the patient shall be observed for compliance with instructions. The expirations shall be checked visually for reproducibility from flow-volume or volume-time tracings or displays. The following efforts shall be judged unacceptable when the patient:

1. has not reached full inspiration preceding the forced expiration,

2. has not used maximal effort during the entire forced expiration,

3. has not continued the expiration for at least 5 seconds or until an obvious plateau in the volume time curve has occurred,

4. has coughed or closed his glottis,

5. has an obstructed mouthpiece or a leak around the mouthpiece (obstruction due to tongue being placed in front of mouthpiece, false teeth falling in front of mouthpiece, etc.),

6. has an unsatisfactory start of expiration, one characterized by excessive hesitation (or false starts), and therefore not allowing back extrapolation of time 0 (extrapolated volume on the volume time tracing must be less than 10 percent of the FVC).

7. has an excessive variability between the three acceptable curves. The variation between the two largest FVC's and FEV_1's of the three satisfactory tracings should not exceed 10 percent or ± 100 milliliters, whichever is greater.

b. Periodic and routine recalibration of the instrument or method for recording FVC and $FEV_{1.0}$ should be performed using a syringe or other volume source of at least 2 liters.

III. INTERPRETATION OF SPIROGRAM

a. The first step in evaluating a spirogram should be to determine whether or not the patient has performed the test properly or as described in II above. From the three satisfactory tracings, the forced vital capacity (FVC) and forced expiratory volume in 1 second ($FEV_{1.0}$) shall be measured and recorded. The largest observed FVC and largest observed FEV_1 shall be used in the analysis regardless of the curve(s) on which they occur.

b. The following guidelines are recommended by NIOSH for the evaluation and management of workers exposed to cotton dust. It is important to note that employees who show reductions in FEV_1/FVC ratio below .75 or drops in Monday FEV_1 of 5 percent or greater on their initial screening exam, should be re-evaluated within a month of the first exam. Those who show consistent decrease in lung function, as shown on the following table, should be managed as recommended.

IV. QUALIFICATIONS OF PERSONNEL ADMINISTERING THE TEST

Technicians who perform pulmonary function testing should have the basic knowledge required to produce meaningful results. Training consisting of approximately 16 hours of formal instruction should cover the following areas. Persons who successfully complete the course will be certified by OSHA or their designee.

a. Basic physiology of the forced vital capacity maneuver and the determinants of airflow limitation with emphasis on the relation to reproducibility of results.

b. Instrumentation requirements including calibration procedures, sources of error and their correction.

c. Performance of the testing including subject coaching, recognition of improperly performed maneuvers and corrective actions.

d. Data quality with emphasis on reproducibility.

e. Actual use of the equipment under supervised conditions.

f. Measurement of tracings and calculations of results.

2. Part 1928 of Title 29 of the Code of Federal Regulations is hereby amended by adding a new paragraph (a)(5) to § 1928.21 to read as follows:

§ 1928.21 Applicable standards in 29 CFR Part 1910.

(a) * * *

(5) Exposure to cotton dust in cotton gins—§ 1910.1046

(Secs. 6, 8, 84 Stat. 1593, 1599 (29 U.S.C. 655, 657); Secretary of Labor's Order 8-76 (41 FR 25059); 29 CFR Part 1911)

[FR Doc. 78-17233 Filed 6-19-78; 11:53 am]